Rocking in the Yukon

Yukon
Energy, Mines and Resources

YUKON
GEOLOGICAL SURVEY

106-01304/

Rocking in the Yukon

An overview of mining in the Yukon

August, 2003

Yukon
Energy, Mines and Resources

Yukon
Geological Survey

revised August, 2003

ISBN 1-55362-162-X

Earlier editions published in October 1999, March 2000 and June 2001.

For more information, contact:

Department of Energy, Mines and Resources
Yukon Government
Room 102, 300 Main Street, Box 2703
Whitehorse, Yukon Y1A 2C6

phone (867) 667-5200
fax (867) 667-5150
e-mail: mining@gov.yk.ca
website: yukonmining.com

Cover photo: David Lucas on Mount Albert, by Charlie Roots

Editors: Debbie Abbott, Jeanne Burke, Lori Walton
Production: K-L Services, Whitehorse, Yukon

CONTENTS

Introduction 1

Economies: unique resources 3

Geology: solving the puzzle 15

Mining: a walk through the stages 29

Placer Mining: gold in the wash 35

Mining Responsibly: the times are changing 41

Brewery Creek: a case study 55

Appendix A. Acts and regulations pertaining to mining in the Yukon 61

Appendix B. Glossary 62

Appendix C. Mineral Resources 63

Appendix D. Contacts 65

INTRODUCTION

The end products from local and global mining of minerals are an important part of our everyday lives. Examples can be found in our homes: the convenience of copper wiring that allows us to turn on the lights, gypsum in wall board and gold and silver in computers. Our vehicles rely on lead in batteries and zinc in car bodies.

Many mining products also have an extended life through modern recycling technology. The smelters for newly mined and recycled minerals rely on coal as the major source of power, another product of mining. Our modern lifestyles are more connected to the mining industry than many of us realize.

This booklet provides an overview of mining and mineral resources in the Yukon. We hope it provides you with a good understanding of the importance of our mining industry and the benefits it provides to many Yukon people.

William Lebarge

Yukon Geological Survey staff provide key support for the development of mining in the Yukon.
From left to right: (back) Don Murphy, Grant Abbott, Jeff Bond, Roger Hulstein, Karen Pelletier, Ken Galambos,
Mike Burke, Maurice Colpron, Derek Thorkelson, Rob DeKlerk, Charlie Roots, Grant Lowry.
(front) Jesse Duke, Rod Hill, Bill Lebarge, Lee Pigage, Ali Wagner, Lara Lewis, Amy Stuart, Craig Hart,
JoAnne vanRanden, Julie Hunt, Diane Emond, Panya Lipovsky, Monique Raitchey and Steve Traynor.

YUKON FACTS: SETTING THE STAGE

Population
29,960 (December 2002)

Area
483,450 square kilometres
(4.8% of Canada's total land area)

Major sectors
government, tourism, mining

Real GDP by industry
$1.055 billion (2001, in 1997 dollars)

Value of metallic mineral production (gold and silver)
$31.414 million (2002)

Mineral exploration expenditures
$6.9 million (2002)

Mineral development expenditures
$550,000 (2002)

Fur production
$356,648 (estimate 2001)

Primary forest production
69,500 cubic metres (2000-2001)

Tourism: There were 345,010 travellers entering the Yukon through Canada Customs Points of Entry in 2001.

Retail trade
$363 million (2001)

Value of real estate transactions
$103.5 million (2002)

Average house selling price
$161,300
(Whitehorse, quarter 4, 2002)

Median rental rates
1 bedroom $640/month
2 bedrooms $675/month
(Whitehorse, March 2003)

Residential power rate
first 1,000 kilowatt hours,
9.86 cents per kWh
over 1,000 kilowatt hours,
10.45 cents per kWh
(June 2003)

General service power rate
first 2,000 kilowatt hours,
8.31 cents per kWh
over 2,000 kilowatt hours,
10.45 cents per kWh
(June 2003)

Minimum wage
$7.20/hour (April 2003)

Average wages and salaries
$40,523 (2001)

Official gemstone
lazulite

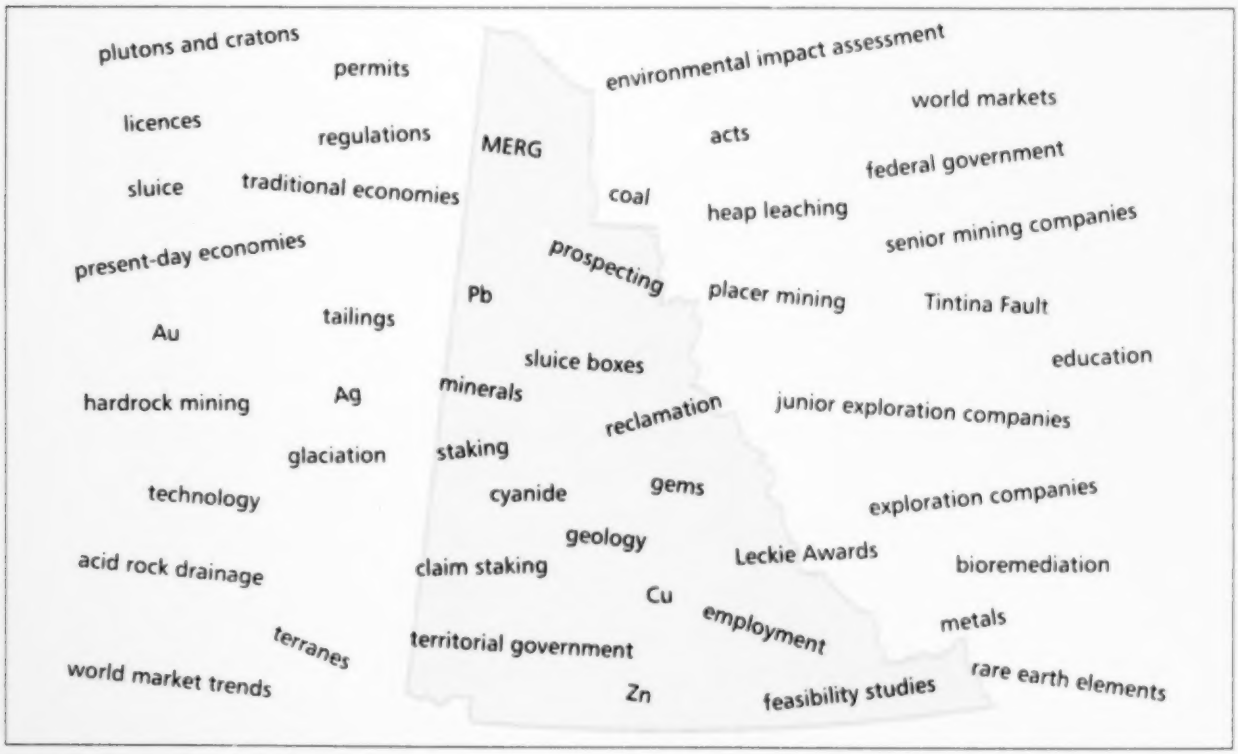
Official bird
raven

Floral emblem
fireweed

Yukon tree
sub-alpine fir

Principal rivers
Donjek, Klondike, Liard, MacMillan, McQuesten, Nisutlin, Peel, Pelly, Porcupine, Ross, Snake, White, Wind, Yukon

Principal lakes
Aishihik, Bennett, Dezadeash, Frances, Kluane, Kusawa, Laberge, Little Salmon, Marsh, Mayo, Quiet, Tagish, Teslin



Here are some of the mining terms you will become familiar with in this overview. A glossary on page 62 defines many of them.

ECONOMIES: UNIQUE RESOURCES

Mineral exploration and production have been the most significant non-government economic forces in the Yukon for over 100 years. The mining sector has accounted for as much as 28 per cent of the Yukon's Gross Domestic Product (GDP). For this reason, much of the Yukon's infrastructure, support services and skilled workforce has been geared towards supporting the mining industry.

According to Industry Canada, between 1993 and 1998, the runaway leaders of Yukon products exported to the world were zinc and lead concentrates. In 1996, when the Faro lead-zinc mine was in full operation, production from Yukon mines accounted for 2.1 per cent of total world zinc production and 3.2 per cent of total world lead production. For a small economy, the Yukon has made a relatively significant contribution to global lead and zinc production.

The giant lead-zinc mine at Faro, when fully operational, was also a significant contributor to the local Yukon economy representing an estimated 12 to 15 per cent of the Yukon's Gross Domestic Product, and an estimated 70 to 85 per cent of the Yukon's mineral production. However, the Faro mine ceased production in 1998.

The Brewery Creek gold mine, operated by Viceroy Resource Corporation between 1997 and 2001, produced 266,000 ounces of gold.

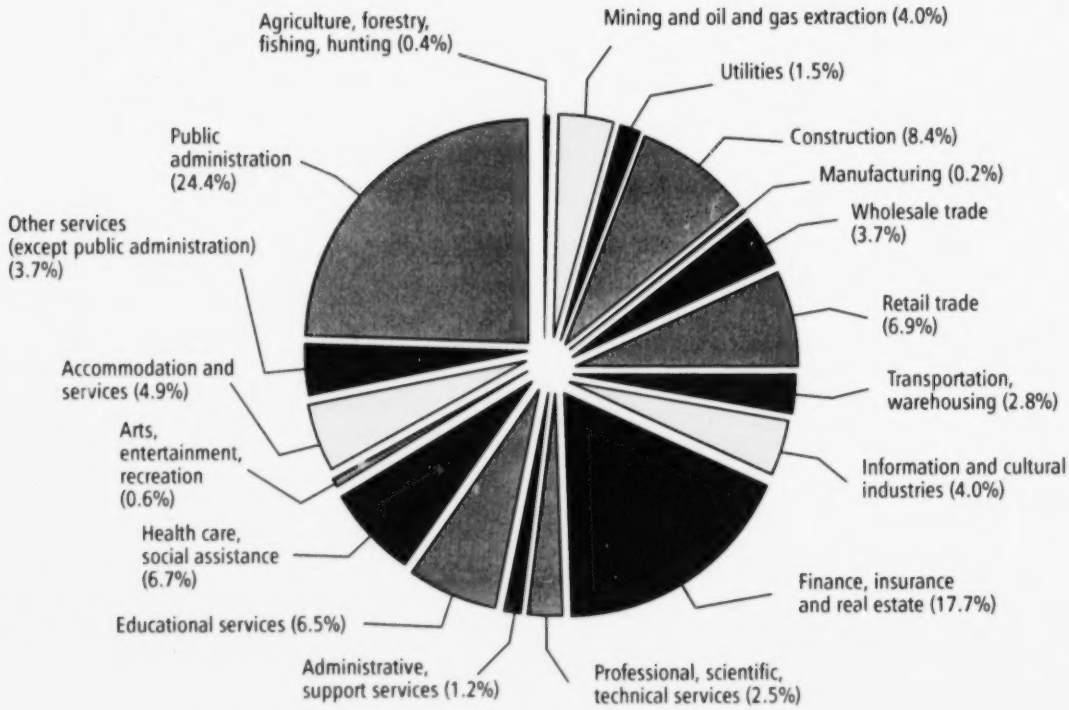
Exploration expenditures for 2002 were estimated to be $6.9 million, down from $7.2 million in 2001. Exploration in 2002 was directed towards precious metals such as gold and silver, and base metals such as copper, lead and zinc. Slightly more was spent on the search for precious metals. There was even money spent on exploring for emeralds. Expenditures should rise in 2003 due to higher commodity prices and an increase in speculative investors.

In 2002, there were 115 active placer mines in the territory.

Yukon government

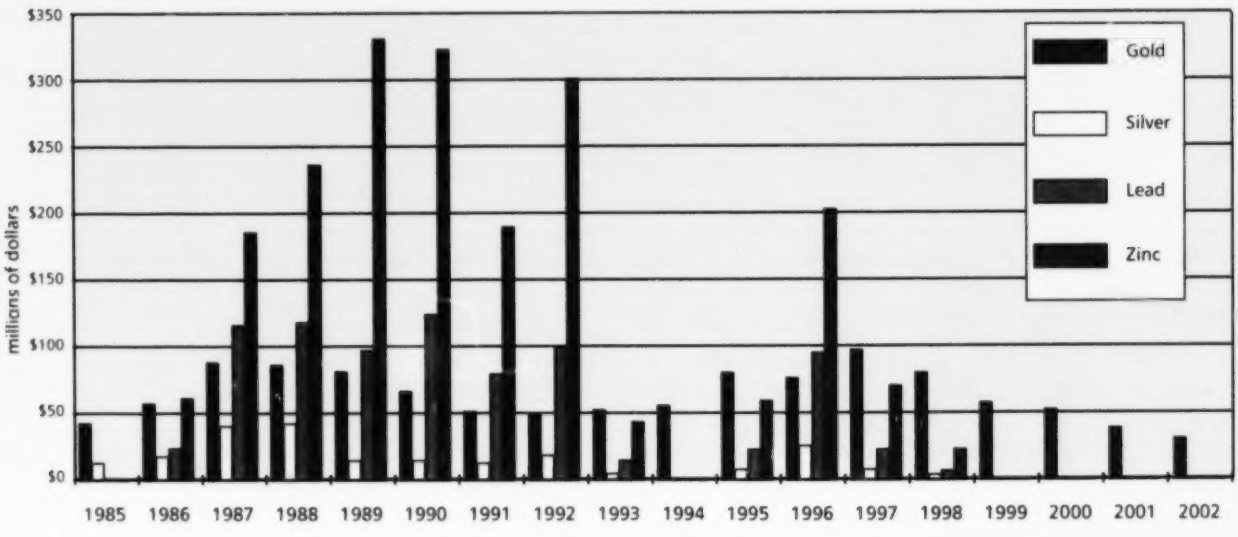
Weighing gold with a scale, at the Bleiler placer mine.

YUKON GROSS DOMESTIC PRODUCT, BY INDUSTRY, 2001


Agriculture, forestry, fishing, hunting (0.4%)
Mining and oil and gas extraction (4.0%)
Utilities (1.5%)
Construction (8.4%)
Manufacturing (0.2%)
Wholesale trade (3.7%)
Retail trade (6.9%)
Transportation, warehousing (2.8%)
Information and cultural industries (4.0%)
Finance, insurance and real estate (17.7%)
Professional, scientific, technical services (2.5%)
Administrative, support services (1.2%)
Educational services (6.5%)
Health care, social assistance (6.7%)
Arts, entertainment, recreation (0.6%)
Accommodation and services (4.9%)
Other services (except public administration) (3.7%)
Public administration (24.4%)

Yukon Bureau of Statistics

VALUE OF MINERAL PRODUCTION IN THE YUKON



Yukon Bureau of Statistics and Natural Resources Canada

WORLD GOLD PRICE AND VALUE OF GOLD PRODUCTION IN THE YUKON

UP AND DOWN: WHY?

Mining, like any other business, is driven by a combination of supply and demand. The need for the metal-based products that we use every day drives the demand for raw and finished metal products.

The location and quantity of mineral-rich deposits depend on geological factors. The best find is near-surface rock with a high content of minerals (high grade). It is more expensive to extract minerals when they are less concentrated or low content (low grade). However, global economic conditions impact where the extracted minerals will come from, where they will be processed, how much they are worth, and who will make a profit. For example, a low-grade deposit may become economically feasible to mine as demand increases. The mining and metal industries, like many other businesses, are highly competitive at a world level.

Global factors, such as the price of metals, directly affect the profitability of a mine. If the mining company cannot sell its product for a profit, it will stop producing until global factors change. Over the years, the law of supply and demand has created a cycle of ups and downs in the Yukon and the worldwide mining industry.

In some cases, political events around the world affect the supply of a particular mineral. For example, when China released tonnes of tungsten on the market in the 1980s, the price decreased significantly. Many mines, including the CanTung mine north of Watson Lake, could not compete with this cheaply produced ore and had to close. The Chinese reserves are decreasing and, as a result, the price of tungsten started to rise in June, 2001. The CanTung mine reopened in January, 2002. (See page 20 for more information.)

The investment climate is driven by the possibility of financial return. Many factors affect the attractiveness of a country at a given time. Political instability can add risk. The lack of skilled labour, infrastructure, or access to resources can add cost to mineral resource extraction.

Exploration activity also follows this supply and demand cycle, and it is subject to the conditions of the investment climate. However, the abundance of significant mineral deposits in the Yukon ensures that there will be a continuing interest in our resources.

Providing power for industry

Aishihik Lake, the only multi-year reservoir on the Whitehorse-Aishihik-Faro power grid system, was built in the late 1970s to provide affordable electricity to large mining projects. This power source makes residential, industrial and commercial development possible. As a result, it significantly reduces Whitehorse's dependence on diesel power in winter. Diesel power is more expensive and has a greater impact on the environment.

ECONOMIES OF SCALE

The Yukon still has potential for the discovery of near-surface, world class mineral deposits. However, exploration trends in the Yukon seem to indicate that smaller deposits with shorter life-spans will be more common — much like the mines developed since the 1980s at Mount Skukum, Ketza River, Brewery Creek, Sa Dena Hes and Mount Nansen. (See the map, page 26.) Currently, almost all Yukon exploration projects in the advanced permitting stages fall into this "short mine life" category. Even the largest of these projects are considering mines with an expected life of 10 to 12 years. These mines require much smaller capital investment and therefore may be easier to finance.

Skagway remains key to Yukon mining success

Located only 160 kilometres from Whitehorse by an all-weather road, the port of Skagway is a deep-water, ice-free, year-round Alaskan port. Facilities include a 10,000-square-metre ore concentrate storage warehouse and 100,000 square metres of open storage. It has been designed and equipped to handle out-bound ore concentrates from Yukon mines. Water depth is 12.8 metres at the dock face, and the docks are commonly used by large ore transport ships. The port of Skagway is 760 kilometres closer to Japan than is the port of Vancouver.

NEW TECHNOLOGY

Mining has become increasingly efficient, and new technologies have now made lower grade deposits economically viable. Increased process efficiency and streamlining, combined with the economies of scale, have made large volume mining viable in short time periods. These changes are reflected in the metal prices on the stock market. The prices show consistent downward trends. This is not due to reduction in value, but reflects the competitive nature of mining at consistently lower prices.

EMPLOYMENT

Despite its cyclical nature, the mining industry is still key to the Yukon economy. Although exact figures are difficult to find, it is generally agreed that, in good mining years, hardrock mines employ more than 1,000 people and placer mines employ 600 to 700 people. In a territory of about 30,000 people, this direct employment from mining has an important economic impact. These figures do not include others who are involved in mineral exploration such as prospectors, geologists, surveyors and construction workers.

The economic impact of mining extends well beyond those who work at the mines or those who are looking for new mines. Economists refer to this impact as a "multiplier" and multiply the number of jobs in a sector to derive the total impact on a region. In the Yukon, one and a half is the multiplier for the mining industry. This means that for every person employed in mining, an additional half job is created elsewhere in the economy.

THE "MULTIPLIER EFFECT" Examples of goods and services

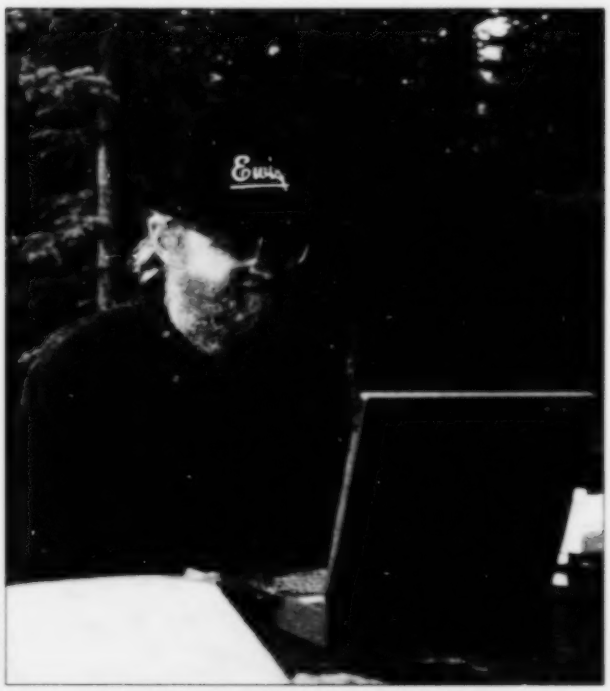
- Accommodation
- Air support
- Air transportation
- Aircraft charter
- Airfreight
- Airstrip management
- Architectural services
- Assay services
- Automotive supplies
- Baking
- Banking services
- Bearings and seals
- Belts, liners and fasteners
- Boilers
- Building supplies
- Bus and taxi services
- Clothing
- Compressors and spares
- Computers and computer supplies
- Concentrate handling
- Cooking and catering
- Core boxes and storage racks
- Crushing and grinding
- Diesel oil
- Drill steel and bits
- Drilling contractors
- Dust collectors
- Electrical supplies
- Electronic appliances
- Engineering services
- Engines (gas and diesel)
- Environmental services
- Expediting services
- Explosives
- Fans and blowers
- Filters and cloth
- Fire fighting equipment
- Furniture
- General contractors
- Generators
- Geochemical services
- Groceries
- Heating systems
- Hoses, tubes and fittings
- Lumber and timber
- Medical supplies
- Office services
- Office supplies
- Paint
- Pilot services
- Reagents and supplies
- Repairs and replacement parts for machinery and vehicles
- Rescue and safety equipment
- Road maintenance
- Shelving
- Storage sheds
- Telephones and communications
- Tools
- Water treatment

Money spent on mineral exploration flows to local businesses

Studies in other jurisdictions demonstrate the positive economic impact of mineral exploration. Manitoba reports that every dollar spent by government through its mineral incentive program generates nearly $5 in mineral expenditures, plus an additional $2 in business income. In Alaska, at least 65 per cent of $35 million in certified exploration expenditures flows directly to local businesses.

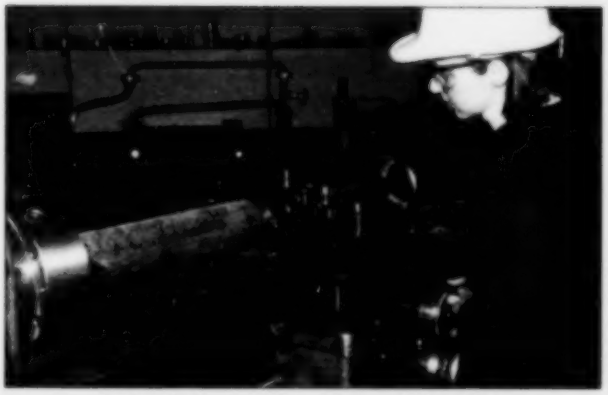
In areas where secondary processing of ore occurs, or additional value is added through the manufacturing of finished products, the multiplier effect is larger.

Most Yukon communities are affected by the economic activity that results from the mining industry. Most of the Yukon's main highways, with the exception of the Alaska Highway, were developed because of mining projects. These roads are now access routes for many tourist and recreational destinations. They keep goods, services and people circulating easily between communities.



Daniele Héon

Geologist Don Murphy, Yukon Geological Survey, entering data in the field.



Yukon government

A tinsmith apprentice, Advanced Education.

Work opportunities

Images of a mine worker with pick and shovel in hand no longer apply to the changing mining workplace of today and tomorrow. A modern mine worker needs training in mathematics and computer technology. New technologies have become an integral part of the mining industry. One example is the use of global positioning systems (GPS) to fix the location of soil, silt and rock samples collected during an exploration program. This information is then entered into a Geographic Information System (GIS). A GIS is a system of hardware, software and personnel used for the storage, retrieval, mapping and analysis of the geographic data created from this field information. With GIS, data analysis becomes more efficient compared to the manual methods of the past. Mining companies can analyze, create and present digital maps with multi-dimensional layers and information from their field and drilling data.

Mining offers a variety of job opportunities for Yukoners. Each stage in the mining process opens the door for local employment. People experienced with bush survival and the ability to stay in remote camps for extended periods of time are required to stake claims or cut lines. First aid, map reading and compass skills are also important. It is necessary to be in good physical condition.

Prospecting skills, acquired through years in the field, are still very important to mining companies which rely on seasoned prospectors to discover new mineral showings. Prospectors bring their own expertise and insight to a company's search for a resource.

Exploration requires many support services and people such as helicopter and fixed-wing pilots and mechanics.

Camp cooks play a key role in any exploration program and for this reason they are usually well paid. If you have a bad cook, you have a problem!

If exploration reveals a potential mineral-rich deposit, the exploration company will hire surveyors to ensure that claims are in order and properly staked.

Once significant mineral resources have been confirmed, baseline environmental data will be collected. Biologists will identify what flora and fauna are in the area and study local ecosystems. Baseline information on creek water, such as pH, naturally occurring metals, sediment levels, and benthic invertebrate populations will be determined through a water-sampling program. Water quality, fish habitat and populations will be inventoried.

Once this data is established, the condition of the environment can be monitored. Environmental assessment and monitoring are becoming more important components of mining.

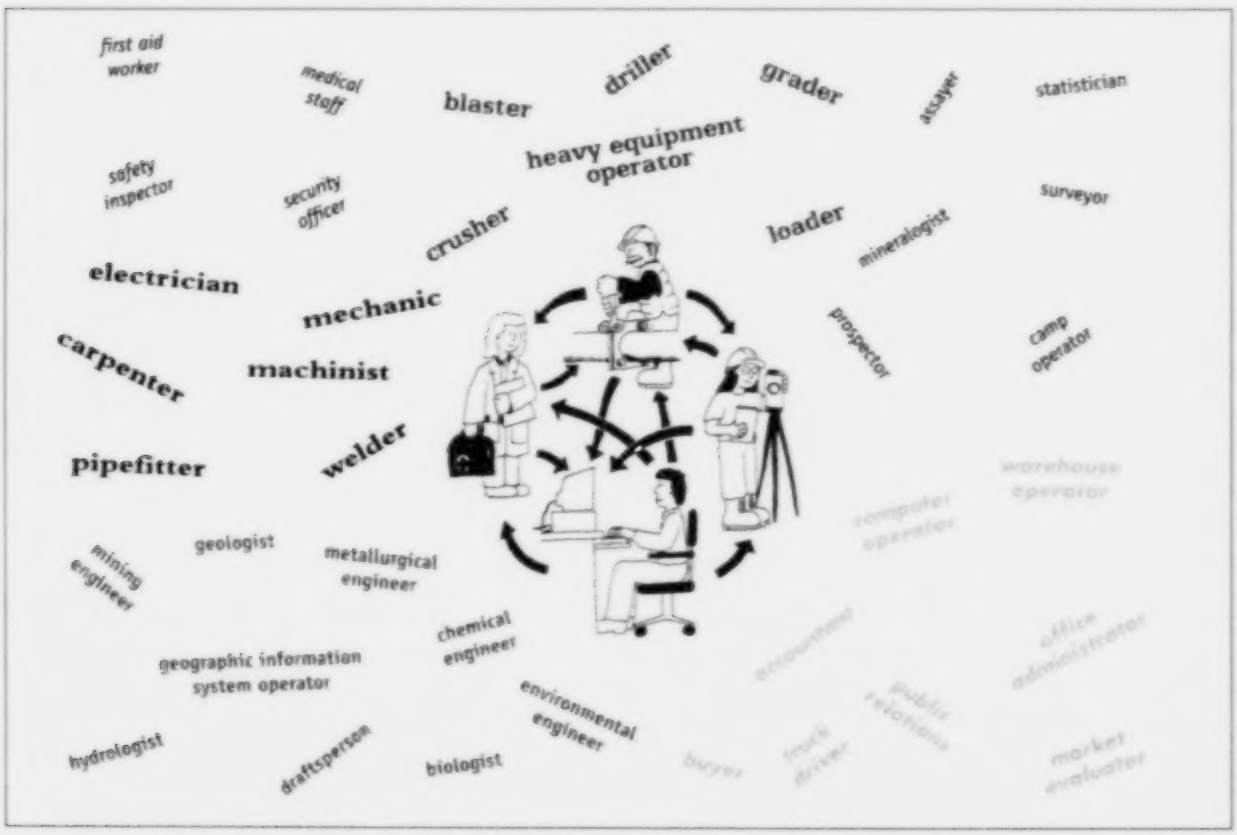
Engineering firms design mines, test the construction designs, monitor the environmental impacts and plan for the reclamation of the site to a more natural state.

A variety of tradespeople are required during the building and production phases: electricians, carpenters, millwrights, heating and ventilation technicians, truck drivers and backhoe operators.

Mills require system control people who can deal with the monitoring and automated equipment in a modern-day mill.

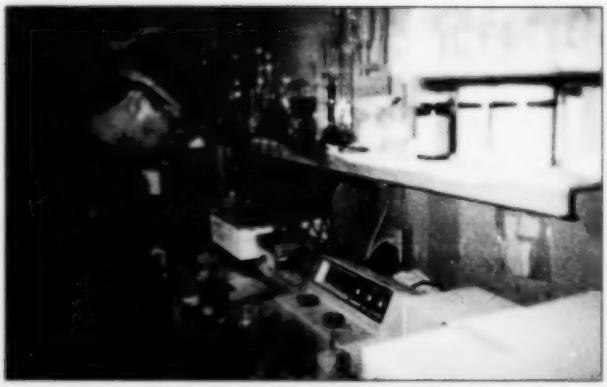
Many more Yukon people running their own businesses serve the mining industry. Construction companies are directly involved in building mills, roads, dams and dikes for mine sites. As with any large business, accountants, lawyers and clerical and secretarial services are required.

Even after a mine shuts down, environmental technicians and engineers must complete monitoring and carry out reclamation work to prevent soil erosion and encourage



Rock-on Yukon grade 5 curriculum, Yukon Chamber of Mines

Some employment opportunities available in the mining industry.



Allan Carlick, DIAND

Lab analysis at Brewery Creek.

the area to return to a natural state. Companies often hire contractors to carry out many of these jobs.

Training opportunities

Mining companies may develop socio-economic agreements with Yukon First Nations. These agreements include training and employment opportunities.

At different times, Yukon College offers programs for entry-level mine training, including courses in industrial safety, tools, first aid, hydraulics, heavy equipment maintenance and welding. The majority of graduates find work. These college programs are often client-driven, tailored to different operations and communities. Residents of the community receive enrolment priority.

Often there is a hands-on component at the mine site. In the past, Carmacks-based sessions were held at BYG's Mount Nansen mine where the students learned how to use and maintain the company's equipment. This has also been done at Viceroy's Brewery Creek mine.

Rod Hill

Geologists looking at rock cores.

Yukon government

Mining exploration crew member greasing the ends of a drill rod.

One Whitehorse session continued an extra six weeks after Golden Hill Ventures lent its equipment to the program for practical training.

There are opportunities for students and aspiring geologists to work with exploration geologists during the summer. The scientists in the Yukon Geological Survey often hire student assistants.

Yukon people are sometimes hired on as helpers. For example, diamond drillers are still trained on the job.

The Yukon Chamber of Mines offers annual introductory and advanced courses in prospecting. These courses are recommended for people applying for funding through the Yukon Mining Incentives Program. A Mine Training Trust Fund, administered by an independent board set up by the Yukon Chamber of Mines, has been created to ensure that both Yukon people and mining companies benefit from a trained local labour force.

IMPORTANT MINERAL RESOURCES
Traditional economies

Metal and mineral resources have always had cultural significance for Yukon First Nations people. The values placed on these resources were different from the values of present-day society. Valued resources among First Nations were traded over great distances. These long-established trading practices were highly sophisticated.

Copper

Copper, a highly valued metal of Yukon First Nations, was rarely discarded. Nuggets were collected from the gravels of the White River, Sheep Creek and Bullion Creek by the Southern Tutchone who held the trade monopoly on copper from this region. The nuggets were hammered into thin, flat sheets and cut into desired shapes. Copper sheets were then stacked into layers and hammered together to make highly valued larger pieces. Copper had many uses in Yukon First Nation societies. Knife blades, prongs, hooks, gaffs, awls, arrow points and tubular beads were but a few uses. Copper is still believed to have healing powers.

Obsidian

Natural glass was collected from outcrops and stream beds in the eastern ranges of present-day Kluane National Park. However, many Yukon First Nations also

Yukon government

Copper sculpture at the Beringia Centre, Whitehorse, Yukon. Artists: Mark Porter, Brian Walker, Keith Wolfe-Smarch

obtained obsidian from Mount Edziza, near the Stikine River in northern British Columbia. The Mount Edziza sources were controlled by the First Nations of the area and traded extensively with Yukon First Nations for over 6,000 years. Chunks of obsidian were fractured and shaped into sharp cutting edges, stronger and more perfect than steel.

Red ochre (hematite)

This iron ore was valued as a pigment. Though iron ores are found extensively in the Yukon, very few sources were satisfactory as ochre. An important source of ochre was at Paint Mountain, just east of present-day Haines Junction. Red pigment stones were baked, crushed and pulverized into powder for use on the face and clothing, or for rock paintings.

Iron

There were no local sources of iron. Iron was acquired by Yukon First Nations through trading and was valued for its use in knife blades, axe heads, chisels and fish hooks.

Gold

Traditionally, gold was not considered of economic value to Yukon First Nations. Copper held greater cultural value than gold. Gold nuggets found in stream beds were often discarded. Knowledge of stream beds containing gold was quite extensive among Yukon First Nations of the area.

Angela Sidney describes how her uncle, Skookum Jim, while searching for his two sisters, was involved in staking the discovery claim which precipitated the Klondike gold rush. (The narratives, *Discovery of Gold* told by Angela Sidney, and *My Husband's People* told by Kitty Smith, speak about their relatives, Skookum Jim, Kate Carmack and Tagish Charlie and the discovery of Klondike gold. They can be found in Julie Cruikshank's, *Life Lived like a Story.)*

Place names, a description of the environment

There are words in the languages of Yukon First Nations that describe the environment. Here are some examples:

Klondike is a variation of the Han word *Tr'ondëk.*

Goon Heeni (Tlingit), Gold Creek, is noted for its gold deposits.

T'eish Núulàa (Tagish), Charcoal (Black) Point, is a reference to coal deposits in the area.

Tsambaa'a (Tagish), "Grey Ridge" is a reference to a red ochre deposit.

Thatin Chu (Southern Tutchone), "Woman Creek." It was at this site that a young girl turned into a copper pillar.

Giltana Chu (Southern Tutchone), "Flint Creek" refers to the abundance of flint found in this region.

Cha San Chuà (Southern Tutchone), "Copper Water" is presently known as McInytre Creek, a drainage of the Whitehorse Copper Belt.

Tthekal Chú (Northern Tutchone) is a creek where there is a large deposit of flat rocks used for scraping hides.

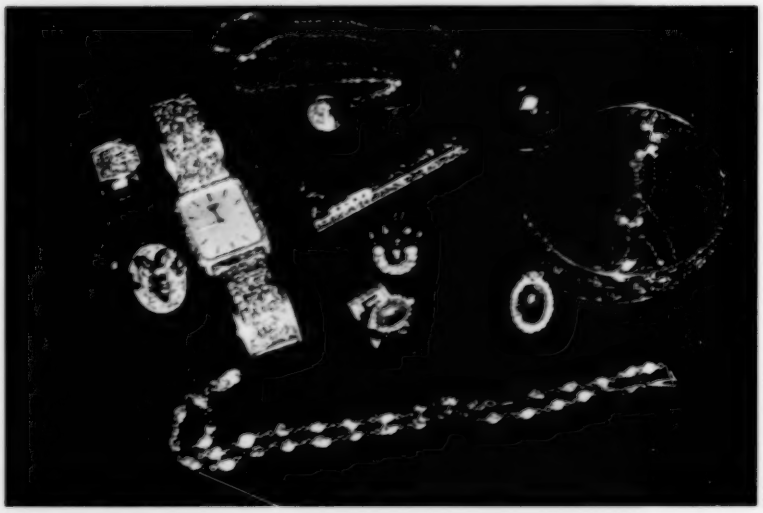
Tsé Dedatl'ise Tué (Kaska), Blue Rock Creek, refers to blue rock in the area.

Chii Deetäk (Gwichin), Rock River, known for its ochre deposit.

IMPORTANT MINERAL RESOURCES
Present-day economies

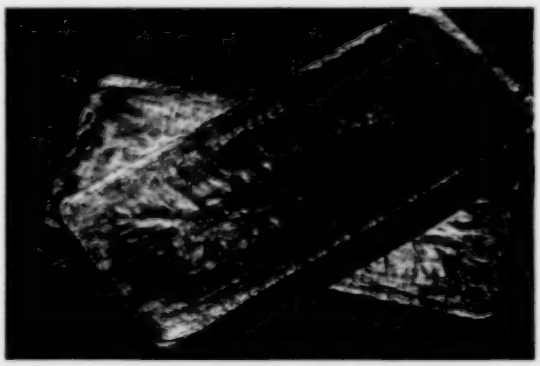
GOLD (Au)

- Gold has been highly valued for thousands of years in the western world. Approximately 3,700 tonnes are sold annually, with jewellery accounting for 80 per cent of gold's use.
- Gold is not affected by moisture or oxygen; it will not corrode or tarnish. It is a good conductor of heat and electricity. These attributes make it useful for electronics, dentistry and coins.
- Gold is a soft metal that is often alloyed to increase its strength. The purity of gold is described according to carat weight. Pure gold is 24 carat or 1000 fine.



Yukon government

Gold and silver ***Jewellery***



Yukon government

Gold ***Bars produced at Brewery Creek***

- Gold contributes to the efficiency and quality of our modern technologies. Gold is found in the following products: radar equipment, aircraft windshields, navigation circuitry, cameras, computers, camcorders, televisions, electronic circuitry, microchips, electrical contacts in airbags, and wheel contacts and connectors to prevent spinning and loss of traction in some vehicles.

SILVER (Ag)

- Globally, 19,100 tonnes of silver were produced in 2002.
- The light sensitivity of silver salts makes silver an integral part of the photographic process. It is used in the manufacture of film, photographic paper, x-ray film, photo-offset plates and other light sensitive products.
- Silver has the best thermal and electrical conductivity of all known metals.
- Silver is also used in the following products: contact and conductor products for the electrical and electronic industry, mirrors, dental amalgams, bearings, jewellery and silverware.

Yukon government

Gold and silver ***Computers at Hidden Valley School***

LEAD (Pb)

- Lead is the world's fifth most used and most-recycled metal. Nearly 80 percent of the lead in the western world is recovered. Most recycled lead comes from batteries.
- Over six million tonnes of lead are produced annually in the western world. Consumption has increased by two per cent per annum.
- Batteries account for over two-thirds of all lead consumption, with the predominant use being in car batteries. The average car battery contains 10 kg of lead. It can also be found in battery powered vehicles such as wheel chairs, golf carts and electric cars. The batteries that drive these vehicles are emission free and, using recycled lead, can easily be manufactured in high volumes for a low cost.
- Other uses of lead include: alloys, pigments, chemicals, fine crystal and stained glass windows. Products with lead also provide protective barriers from noise and air pollution, and radiation.
- Despite its many uses, lead is toxic. If ingested and absorbed into the blood stream, it can cause adverse health effects in animals and humans.

ZINC (Zn)

- Zinc is the world's fourth most used metal, after steel, aluminum and copper.
- Approximately 7.6 million tonnes of zinc are consumed annually in the western world. Consumption has increased by two per cent per annum since 1980.
- Products of zinc include: automobiles, roofing materials, coins, faucets, multi-vitamins, galvanizing agents, anti-corrosive plating, skin cream, die casting, pharmaceuticals, cosmetics and the kitchen sink.
- Zinc is completely recyclable without any loss to its physical and chemical properties.
- Zinc is essential to human health. Adults require a daily intake of 15 mg of zinc.
- Zinc has healing properties that are useful in throat lozenges, sunscreens, first aid ointments, baby lotions and dandruff shampoo.

Yukon government

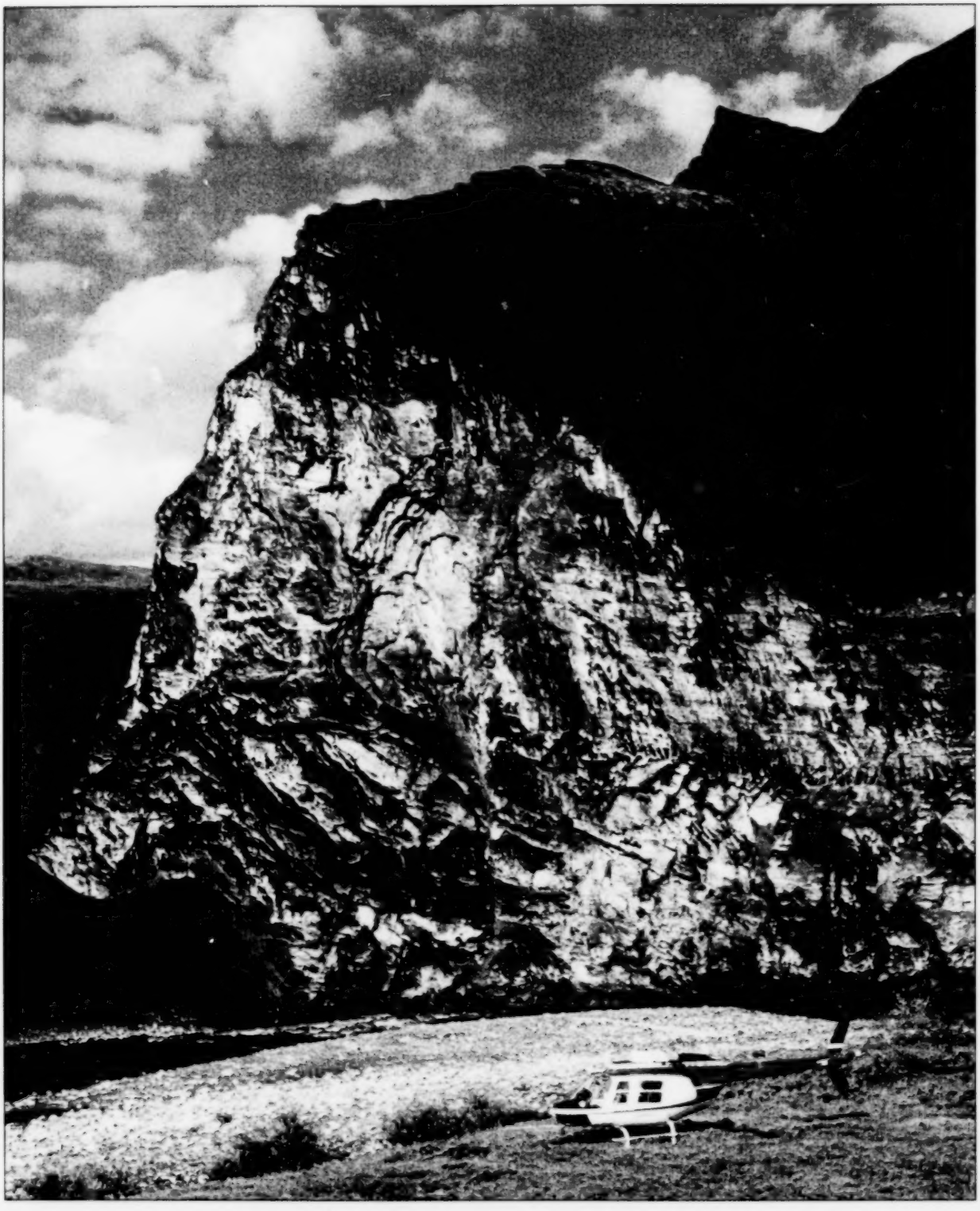
Zinc, lead and copper ***Mic Mac Motors, Whitehorse***

COPPER (Cu)

- Approximately 15 million tonnes of copper are consumed annually in the western world. Consumption has increased by three per cent per annum since 1980.
- Copper has superior electrical and thermal conductivity. Seventy per cent of all copper mined is used in wiring and cable. Copper can also be found in plumbing, appliances and hardware.
- For centuries, copper has been used worldwide as a roofing metal on buildings and churches, and for sculpting.
- Copper is combined (alloyed) with zinc to make brass. Brass is combined (alloyed) with tin to make bronze. These decorative alloys are found in sculptures, jewellery and furniture.
- Copper is essential to human health. Adults require a daily intake of 2 mg of copper.

Yukon government

Gold and silver ***Mayo weather station***



Rod Hill

The National Museum of Nature sent a crew to look for unique lazulite in phosphate-rich ironstone in the Rapid Creek area in northern Yukon.

GEOLOGY: SOLVING THE PUZZLE

The Yukon's geology is complex and full of surprises. Over the years, areas previously explored for minerals have been revisited with innovative technology and geological modelling, resulting in the discovery of new deposits. The complex geological history of the Yukon's rocks, combined with the fact that our territory has not yet been fully explored, creates the potential for large discoveries.

THE YUKON'S GEOLOGY

The Yukon's geology can be roughly split into two rock groups: those north of the Tintina Fault and those south of it. This dividing line cuts northwest to southeast across the territory from Alaska to northern British Columbia.

Each side of this boundary is characterized by different types of rocks containing different types of mineral deposits, some being mined or explored, and many yet to be discovered.

The Tintina Fault

This extensive feature, although inactive today, is a zone where fragments of the earth's crust slid sideways. Most geological evidence suggests that the rocks southwest of the fault moved northwest by at least 450 kilometres, and perhaps as much as 1,200 kilometres.

The Tintina Trench is the sizeable valley formed by the erosion of the Tintina Fault zone. It is one of the most distinctive and significant physical features of the territory. The communities of Ross River, Stewart Crossing, Faro and Watson Lake are located in the trench. (See map, page 17.)

Don Murphy

Looking across the Ings River, near the Campbell River, Pelly Mountains, east of the Tintina Trench.

"Good Old" North America

Northeast of the Tintina Fault are the components of the ancient North American continent which is underlain by a very old stable part of the Canadian Shield.

Exploration has led to the discovery of copper-lead-zinc deposits. Gold, copper and uranium have been found in breccia. Breccia refers to rocks which have been shattered by very hot gases and fluids heated by deep molten rock, or broken by fault movement. In the process of this rock splitting, minerals are precipitated and cement the rock fragments together.

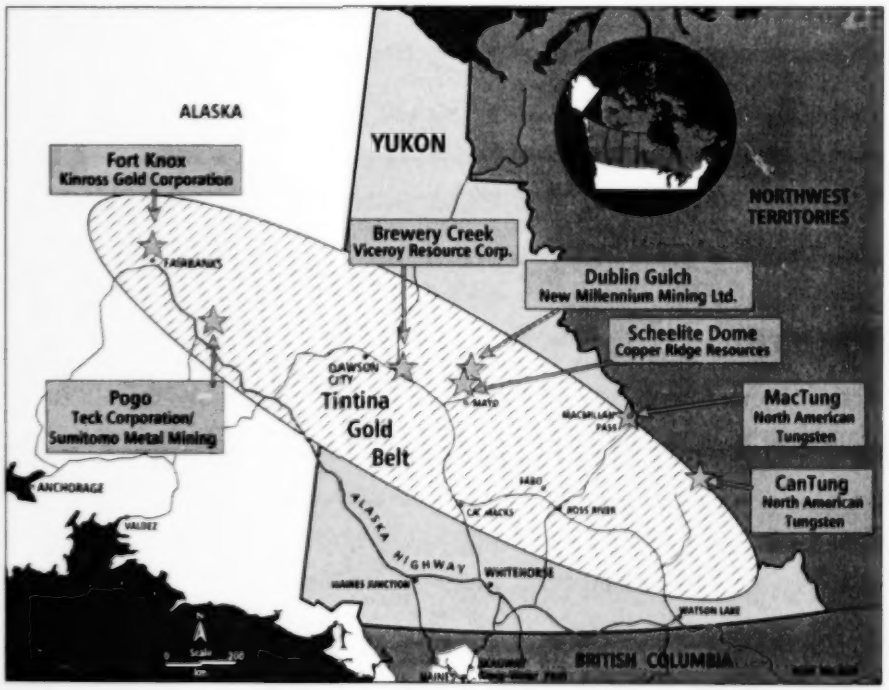
Important lead-zinc deposits are found in a large area of sedimentary rocks called the Selwyn Basin. Most of the Yukon's base metal production comes from these

THE TINTINA GOLD BELT: The hardrock mining gold rush of the new millennium?

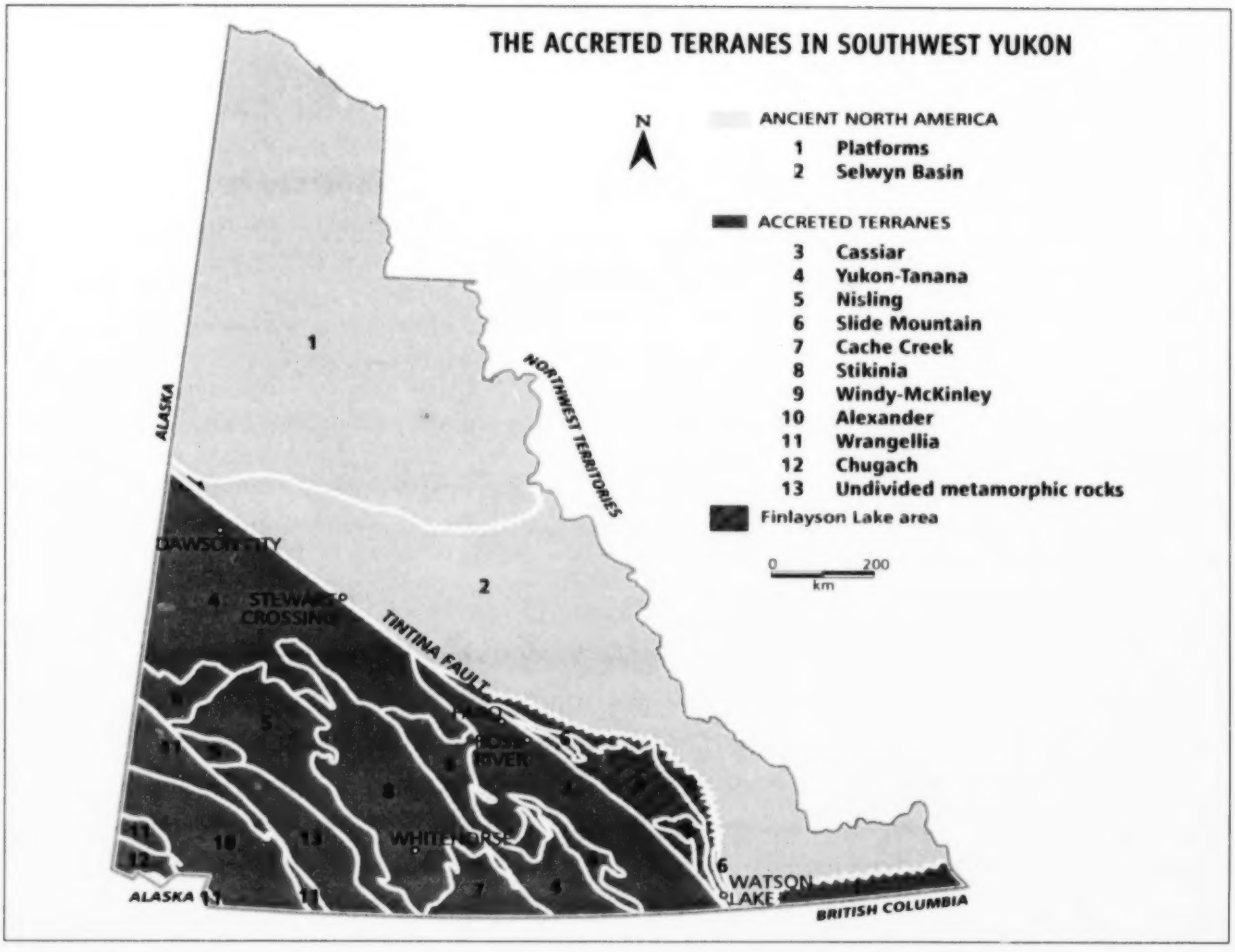
The Tintina Gold Belt contains mineral deposits rich in gold, silver, tin, copper and tungsten. In the Yukon, this belt has produced over 30 million ounces of gold and contains an additional 40 million ounces of gold reserves. Several large deposits in Alaska have been found within this geological zone, including the high-tonnage, low-grade, Fort Knox gold deposit and the high-grade Pogo deposit.

In geological terms, the Tintina Gold Belt includes an array of 92-million-year-old granitic rocks belonging to the Tombstone Plutonic Suite. This suite, or family of rocks, consists of plutons spread across a 550-kilometre zone situated between Dawson City and the MacMillan Pass. Mineralization is concentrated in the plutons but exploration has revealed that deposits may be present even in the surrounding rocks. The Brewery Creek mine, the Yukon's first heap leach gold mine, is related to rocks belonging to the Tombstone Plutonic Suite.

The Tintina Gold Belt also hosts world class tungsten deposits (CanTung mine and the MacTung deposit) and various tin and copper occurrences. In addition to hard rock gold production, the Tintina Gold Belt has produced 190 million ounces of silver and more than 500,000 ounces of placer gold.



Major gold and tungsten deposits in the Tintina Gold Belt



rocks, most notably the large deposits near Faro. Near Elsa, silver-zinc-lead veins occur along a 30-kilometre belt and have produced more than 6.4 billion grams (186 million ounces) of silver.

The accreted terranes

...*new kids on the block*

Southwest of the Tintina Fault, the accreted terranes, or smaller fragments of the earth's crust, were carried around on oceanic plates until they collided with the margins of ancient North America between 160 million years and 120 million years ago. It created a jumbled mix of different geological formations.

Several copper-gold-molybdenum and copper-gold deposits, including the Carmacks Copper, Casino, and Minto projects, are found within a 100-kilometre belt in terranes located in central Yukon (see map, page 26).

...*Finlayson Lake area*

South of Ross River, massive sulphide discoveries have attracted national interest, spurring exploration booms in 1995 and 1996. These deposits contain large concentrations of copper, zinc, lead, gold, silver and cobalt. There has been extensive exploration in the Finlayson Lake area, including advanced feasibility work at the Kudz Ze Kayah and Wolverine deposits (see map, page 26).

RARE EARTH ELEMENTS

There are 15 rare earth elements (REE) plus three other elements (yttrium, scandium and thorium) that are often included in the rare earth element group (see periodic table, page 19). Elements like lanthanum, cerium and neodymium are less well known than elements like gold, zinc and copper. Many of the rare earth elements are actually quite common. However, it is unusual to find them in large concentrations.

"Good Old" North America

Northeast of the Tintina Fault are the components of the ancient North American continent which is underlain by a very old stable part of the Canadian Shield.

Exploration has led to the discovery of copper-lead-zinc deposits. Gold, copper and uranium have been found in breccia. Breccia refers to rocks which have been shattered by very hot gases and fluids heated by deep molten rock, or broken by fault movement. In the process of this rock splitting, minerals are precipitated and cement the rock fragments together.

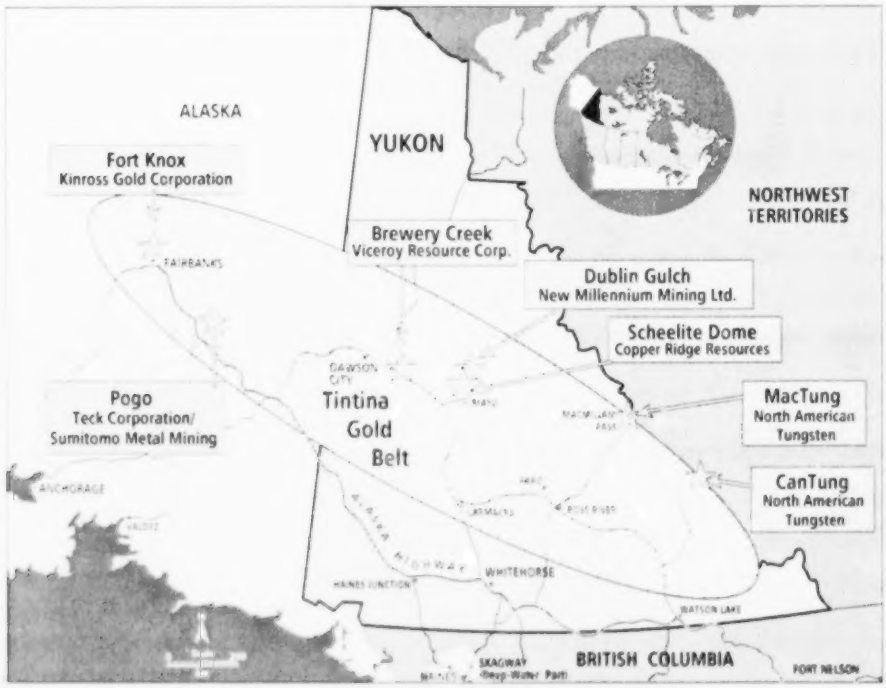
Important lead-zinc deposits are found in a large area of sedimentary rocks called the Selwyn Basin. Most of the Yukon's base metal production comes from these

THE TINTINA GOLD BELT: The hardrock mining gold rush of the new millennium?

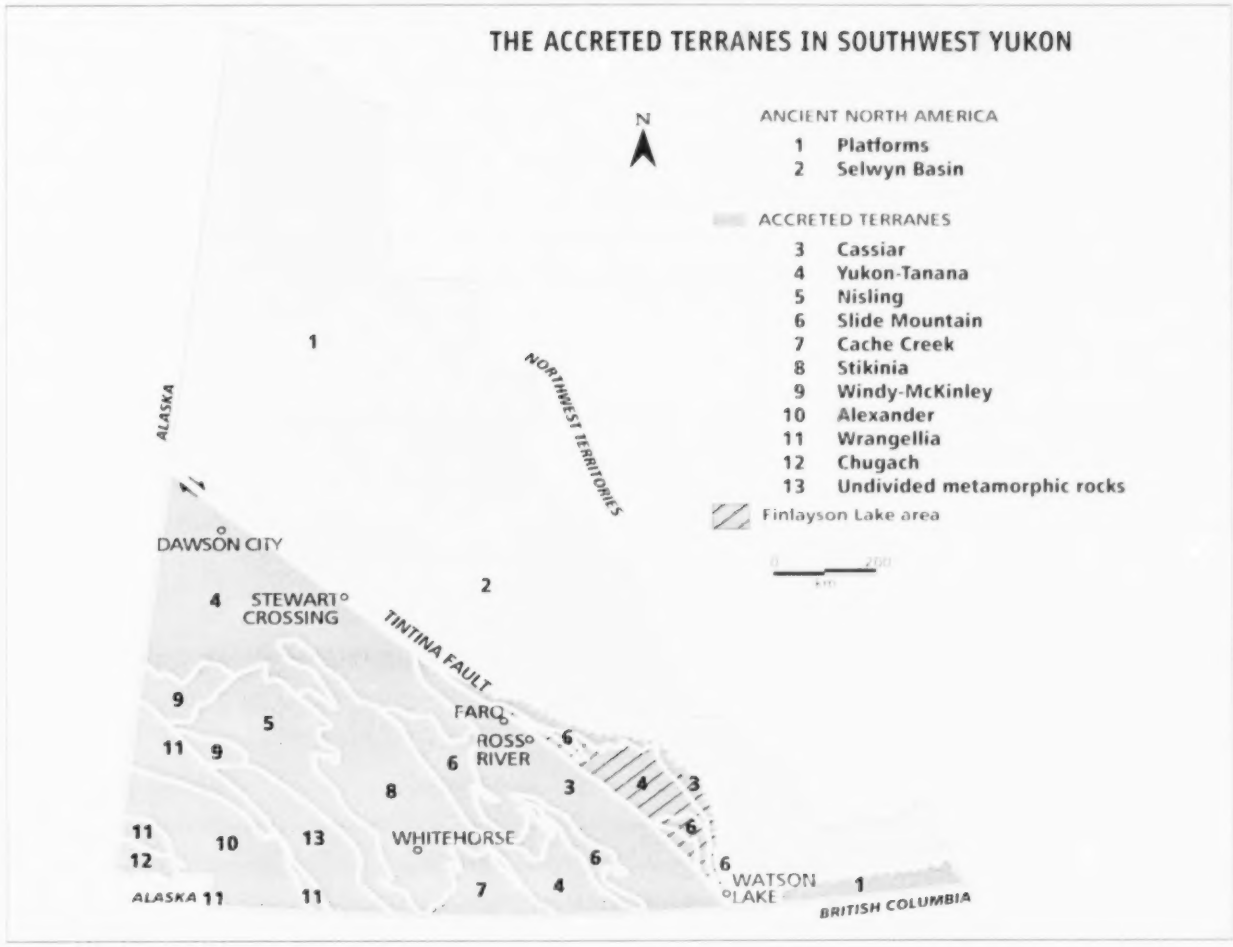
The Tintina Gold Belt contains mineral deposits rich in gold, silver, tin, copper and tungsten. In the Yukon, this belt has produced over 30 million ounces of gold and contains an additional 40 million ounces of gold reserves. Several large deposits in Alaska have been found within this geological zone, including the high-tonnage, low-grade, Fort Knox gold deposit and the high-grade Pogo deposit.

In geological terms, the Tintina Gold Belt includes an array of 92-million-year-old granitic rocks belonging to the Tombstone Plutonic Suite. This suite, or family of rocks, consists of plutons spread across a 550-kilometre zone situated between Dawson City and the MacMillan Pass. Mineralization is concentrated in the plutons but exploration has revealed that deposits may be present even in the surrounding rocks. The Brewery Creek mine, the Yukon's first heap leach gold mine, is related to rocks belonging to the Tombstone Plutonic Suite.

The Tintina Gold Belt also hosts world class tungsten deposits (CanTung mine and the MacTung deposit) and various tin and copper occurrences. In addition to hard rock gold production, the Tintina Gold Belt has produced 190 million ounces of silver and more than 500,000 ounces of placer gold.



Major gold and tungsten deposits in the Tintina Gold Belt



rocks, most notably the large deposits near Faro. Near Elsa, silver-zinc-lead veins occur along a 30-kilometre belt and have produced more than 6.4 billion grams (186 million ounces) of silver.

The accreted terranes

...new kids on the block

Southwest of the Tintina Fault, the accreted terranes, or smaller fragments of the earth's crust, were carried around on oceanic plates until they collided with the margins of ancient North America between 160 million years and 120 million years ago. It created a jumbled mix of different geological formations.

Several copper-gold-molybdenum and copper-gold deposits, including the Carmacks Copper, Casino, and Minto projects, are found within a 100-kilometre belt in terranes located in central Yukon (see map, page 26).

...Finlayson Lake area

South of Ross River, massive sulphide discoveries have attracted national interest, spurring exploration booms in 1995 and 1996. These deposits contain large concentrations of copper, zinc, lead, gold, silver and cobalt. There has been extensive exploration in the Finlayson Lake area, including advanced feasibility work at the Kudz Ze Kayah and Wolverine deposits (see map, page 26).

RARE EARTH ELEMENTS

There are 15 rare earth elements (REE) plus three other elements (yttrium, scandium and thorium) that are often included in the rare earth element group (see periodic table, page 19). Elements like lanthanum, cerium and neodymium are less well known than elements like gold, zinc and copper. Many of the rare earth elements are actually quite common. However, it is unusual to find them in large concentrations.

Traditionally, rare earth elements were used in the oil refining industry. In recent years, however, new applications for REE have been found in high technology products and research. At the research level, REE are associated with super-conductors, new battery compounds, low-cost automobile catalytic converters, high quality optics and lasers, and magnets found in most new electric motors. Although there are REE mines in California and Brazil, China controls over 70 per cent of world supplies.

Geologist James Dodge holds a rare earth claim, called the Lancer (from Lanthanum and Cerium) deposit, in the headwater country of the Ketza River, south of Ross River. Dodge, who is in his 80s, holds several degrees in geology. He still spends 60 to 70 days a year in the field, generally solo. He first worked in the Yukon in 1960 and has returned here frequently over the years.

With the assistance of the Yukon Mining Incentives program, Dodge was able to survey the area. He found it contained a larger and richer vein than previously thought. Assay work, supported by the Canada/Yukon Mineral Development agreement, showed commercially viable concentrations of REE.

In addition to the 15 rare earth elements, the assay report also identified concentrations of niobium and yttrium. Niobium is used in the extremely strong steel alloys that find their way into rocket chassis and jet engines, among other applications. Dodge estimates the claim contains one to two per cent of known world reserves, which he tentatively values in situ at US$300 million.

So why isn't there a mine on the Lancer property right now? REE deposits are expensive to process. They are generally found in extremely small particles. This means that the ore-bearing rock must be ground very finely, or as Dodge puts it, "finer than table salt but coarser than flour." This is both expensive and time consuming. Although the individual metals are often highly sought after by industrial users, the concentrate itself would have to be sold to a very limited number of specialized refineries in the world. These complications make it difficult to find venture partners.

If, however, rare earth applications continue to be found in the fast moving world of high technology research, then REE could quickly become a very valuable commodity indeed.

MY DAD'S A GEOLOGIST AND...

Interview with Melissa Mann, 10 years old

...he's out of town a lot, sometimes for weeks, sometimes for months...then he'll be home for a while... usually he's home more than he's gone...

This is usually one of the first things we learn about geologists, the amount of time spent away from family and friends, working in the field. But it sounds like an interesting life.

...sometimes he gets new rocks and has to look at them...he usually tells me what kind it is, 'cause he knows most of the kinds and sometimes he'll show me where he got them...on a map. He's got lots of rocks at our house. Outside. Inside. In his office... I know some kinds, just a few though, like the kinds in the yard.

Geologists study how the surface of the earth has formed over great time periods. It is like a jigsaw puzzle where important pieces of the story are discovered each field season. These discoveries enrich our lives by giving us knowledge about our planet. This is very important as it gives exploration geologists clues to where there might be important mineral deposits.

Bill Mann

Melissa preparing drill core.

There are other interesting experiences and knowledge of nature that can be brought home and shared after working in the field.

...once he was hiking in the mountains and he found a mountain goat horn or something...it was really old and fragile...we have a moose antler in the backyard too...

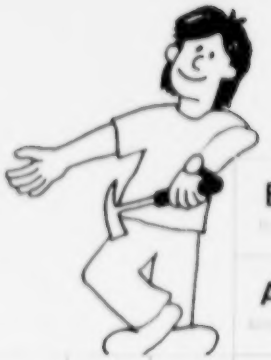
H Hydrogen																	He Helium
Li Lithium	Be Beryllium											B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon
Na Sodium	Mg Magnesium											Al Aluminum	Si Silicon	P Phosphorus	S Sulfur	Cl Chlorine	Ar Argon
K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton
Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon
Cs Cesium	Ba Barium		Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon
Fr Francium	Ra Radium																

La Lanthanum	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium
Ac Actinium	Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium	Am Americium	Cm Curium	Bk Berkelium	Cf Californium	Es Einsteinium	Fm Fermium	Md Mendelevium	No Nobelium	Lr Lawrencium

adapted from Rock-on Yukon grade 5 curriculum, Yukon Chamber of Mines

Rare earth elements

Other elements often included in the rare earth element group



H																	He
Li	Be											B	C	N	0	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc Scandium	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y Yttrium	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra																

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Ac	Th Thorium	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

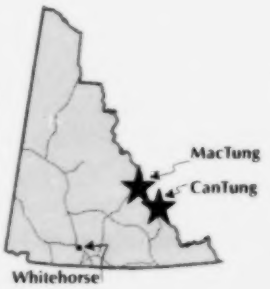
Adapted from Rock · on Yukon grade 5 curriculum, Yukon Chamber of Mines

Rare earth elements

Other elements often included in the rare earth element group

A METAL OF THE 21st CENTURY: TUNGSTEN

If your morning routine included turning on a light, having a warm shower, heating up your coffee in the microwave, or watching the news on the television, you used tungsten! Looking back in time, the invention of the tungsten light in 1911 brought an end to gas lighting, and the dawn of affordable illumination. Tungsten has Swedish linguistic origins; "tung" means heavy, and "sten" means stone. The chemical symbol W is derived from the German word "wolfram," the name used by workers at medieval smelters. It was said that tungsten devoured tin "like a wolf eats sheep."



Fifteen percent of the western world's known tungsten reserves lie on the MacTung property in the mountains of eastern Yukon along the Northwest Territories border. Just across the border and south of the MacTung property is North America's only operating tungsten mine, on the CanTung Property. North American Tungsten Corporation Ltd., a Canadian public company, owns both of these properties. Tungsten was mined actively at CanTung from 1962 until 1986, when CanTung was the largest producer in the western world. In 1986 China flooded world markets with a lower priced commodity. Both properties were dormant until 2002 when CanTung was re-opened. Plans to develop the MacTung deposit are being dusted off and re-visited.

Tungsten is commonly found within the mineral scheelite, which resembles quartz. The interesting challenge in prospecting for scheelite is that it must be done in the dark. This limits prospecting season due to our long Yukon summer days. Resourceful prospectors will drape a black cloth over their heads and use an ultraviolet light to detect the soft blue glow from scheelite.

The following properties of tungsten make it a versatile strategic metal of the 21st century:

HARDNESS: Tungsten is one of the hardest metals known, close to that of diamonds. It is used as an alloy in the manufacture of steel. This added hardness is useful in steel drilling bits, mining tools, metal cutting tools, and bullets. Yukon hunters use bullets with a tungsten core instead of lead. This practice reduces the incidence of elevated lead levels in those eating the harvested foods, and the amount of lead entering the food chain.

TENSILE STRENGTH: Tungsten has the highest known melting point among all metals at 3410 degrees Celsius. It can maintain its tensile strength to temperatures as high as 1650 degrees Celsius. This property is useful in military weapons.

CORROSION RESISTANCE: Tungsten has high corrosion resistance when exposed to mineral acids. This is an important characteristic when tungsten is alloyed with other metals.

THERMAL AND ELECTRICAL CONDUCTIVITY: Tungsten is used in electrical and electronic contacts, wire, rods, and lighting filaments.

Townsite at the CanTung mine.

Mining adit.

both photos, North American Tungsten Corporation

YUKON GEM RUSH?

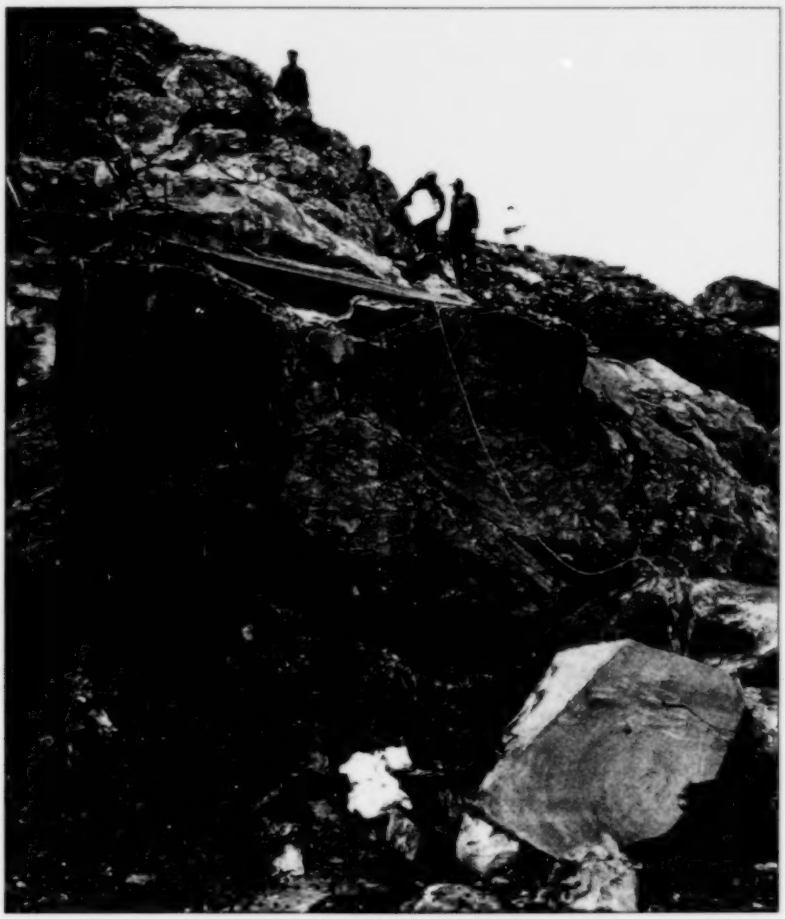
Canadian gemologist Brad Wilson is convinced the geological conditions in the Yukon offer good potential for finding some of the rarest gemstones in the world. Over the past 20 years, he's been coming to the Yukon regularly from his home in Kingston, Ontario.

"I'm looking for gemstones like rubies, sapphires, aquamarine, garnets, topaz and tourmaline," Wilson said. "There are several geological environments in which sapphires occur and one of those environments is in the Yukon. I've found opaque sapphire." These gems form deep in the earth and are tossed out by volcanoes. The magma, which encases the gems, gradually weathers away over millions of years. Any hard crystals, showing a six-sided shape or spindle shape, should be examined.

According to L. Walton, in *Exploration Criteria for Gemstone Deposits and Their Application to Yukon Geology,* many deposits were found by accident. The author suggests that the easiest way to find Yukon rubies and sapphires is to look in streams that lie in areas where volcanic activity occurred and which escaped glaciation. Gemstones can also be found in placer concentrate.

The discovery of diamond-bearing kimberlite in the Northwest Territories has generated a lot of interest in the potential discoveries of gems. In the Yukon, the potential for other gemstones exists and it is quite possible that areas previously prospected, as well as new areas, may show some promise as gem targets.

"I've found some very interesting light green and brownish garnets," Wilson said. "Very few mines in the world are actively producing green garnet. For many years, green garnets were exceedingly rare, and the prices were very high. If I could find a green garnet locality here, that would be great."



Dennis Ouellette

Largest Nephrite jade discovery in the world, King Arctic Mine, north of Watson Lake.

Placing a value on gemstones is very difficult since there is no standard grading system for coloured gemstones as there is for diamonds. Instead, value is based on beauty, rarity, durability, the stone's history and the deposit from which it was mined. Many gems have industrial uses even if they are not "gem quality." Ruby and sapphire are the gem varieties of the mineral corundum. Corundum is mined for its use as an abrasive, polishing or grinding agent.

Favourable geology in the Yukon also exists for tourmaline, aquamarine, topaz and gem garnet.

In 1998, Vancouver-based Expatriate Resources discovered emeralds on one of its exploration properties near Finlayson Lake. True North Gems bought the property, now called Regal Ridge, and continues to explore the extent of emerald mineralization. There are now many companies exploring for emeralds in the Finlayson Lake area. Not only does this area have deposits of copper, lead, zinc and cobalt, but it now has potential as a significant gemstone district.

DIAMONDS IN THE YUKON?

As diamond production grows in our neighbouring territory, NWT, Yukoners wonder why we don't have similar finds here. The plain and simple of it is the geology: NWT is old Precambriam shield which is more common for diamond finds; whereas the Yukon has a jumbled mix of younger geological formations.

Well, don't despair! Exciting news breaking from Anchorage, Alaska in 2002 uncovered a new diamond find in geology very similar to Yukon geology. Diamonds were found on the Shulin Lake property, 72 kilometres north of Anchorage.

In 2002, the Yukon government felt it was time to pay more attention to the historical rumours of Yukon diamond finds, and produced the Yukon Diamond Rumour Map shown on page 23. Note that all reported finds are subject to verification.

In total, there have been more than 20 reported rumours of diamonds or diamond host rock in the Klondike and Sixtymile river areas. This concentration in the Dawson area may be due to the on-going exploration and placer mining activity. The most common host rock for diamonds is kimberlite. Diamonds may travel hundreds of kilometres from where they are originally eroded from the kimberlite if the area was glaciated.

The following highlights are from the notes accompanying the Yukon Diamond Rumour Map:

- Upper Bonanza Creek: Placer miner Jim Conklin reports recovering two "match head sized diamonds" from placer concentrate.
- Clear Creek: Placer miner Nels Harper working with prospector Scottie Tom recovered six small diamonds in 1997.
- Upper Dominion Creek: Tom Morgan purchased two diamonds from placer operations.
- Indian River: There are reports of at least 12 diamonds recovered from placer operations. Pete Risby and Vern Estabrook's operation recovered seven on the Upper Indian River in the mid-1980s. Jim Congdon was reported to have found some diamonds at his placer mine. Placer miner Dennis Foy, recovered one diamond on lower Indian River near Quartz Creek. International Separation System, Inc. from Kelowna, B.C. recovered at least three diamonds.
- Rosebud Creek: Whitehorse prospector Bill Harris heard of a diamond being recovered from a placer operation many years ago.

Looking even further back in time, the Whitehorse Star reported on October 5, 1906,

Yukon Diamonds

Claimed that Sparklers Exist on Dixie Creek

Henry Hebb, a Kluane miner arrived in town a few days ago with a pocket full of stones that were pronounced by all who saw them to be diamonds of purest ray serene. The stones were found on Dixie creek in the Kluane district, imbedded in a blue clay the same as the world's most precious stones are found in South Africa. Hebb left for the outside where he will have the stones tested by experienced lapidaries.

"Henry Hebb, a Kluane miner, arrived in town a few days ago with a pocket full of stones that were pronounced by all who saw them to be diamonds... The stones were found on Dixie Creek in the Kluane district."

As the old saying goes: "All that glitters is not gold," there may be diamonds in our Yukon landscape after all!

YUKON DIAMOND RUMOUR MAP

Accompanying notes available in original publication.

YUKON DIAMOND RUMOUR MAP

Accompanying notes available in original publication.

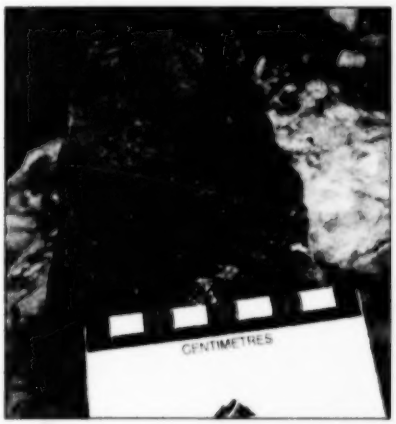
"EMERALDS, A PROMISE OF GOOD LUCK"

Regal Ridge lies in the Pelly Mountains near Finlayson Lake. This majestic ridge took geologist Bill Wengynowski by surprise. While searching for base metals for Expatriate Resources Ltd. late in the 1998 field season, Wengynowski saw what appeared to be malachite (an ore of copper). Closer inspection revealed the find to be beryl. When combined with chromium or more rarely, vanadium, the colourless beryl will take on fascinating shades of green and become an emerald.

Most emeralds in the world come from Colombia; however, fine emeralds also come from Afghanistan, Pakistan, Brazil, Zaire and Zimbabwe. Large emeralds of excellent colour can have a staggering value of over $100,000 per carat, which rivals the value of fine colourless diamonds. Yukon emeralds found on Regal Ridge are a deep and brilliant green.

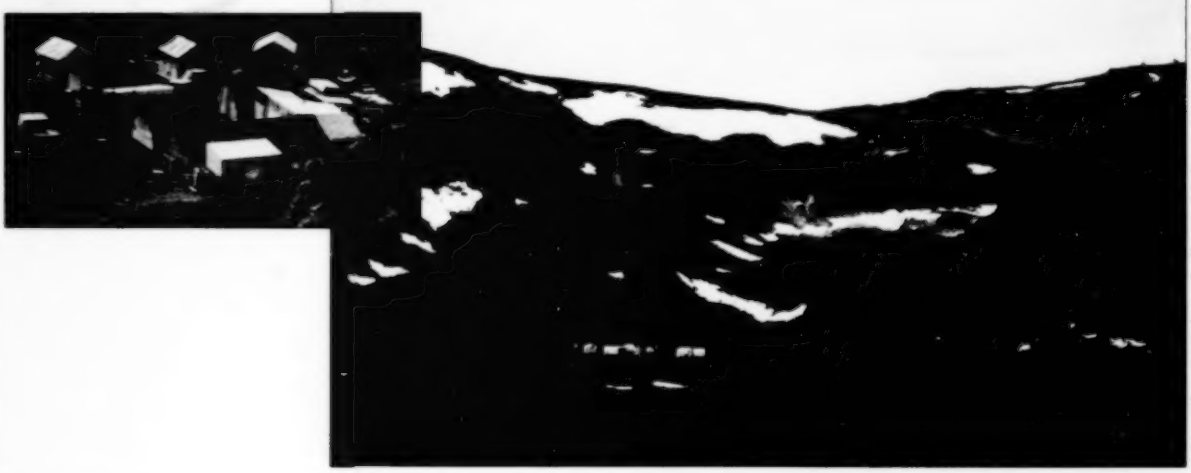
In June of 2002, True North Gems Ltd. acquired the Regal Ridge Emerald Property. The company is exploring the emerald-bearing areas on Regal Ridge by prospecting and sampling, plus diamond drilling and excavating tunnels to explore underground. True North Gems Ltd. is on target to become Canada's first producer of emeralds.

Many gemstone discoveries around the world have been made by children and the general public keeping an eye out for anything unusual. This is good advice for any gemstone enthusiasts enjoying the Yukon outdoors!

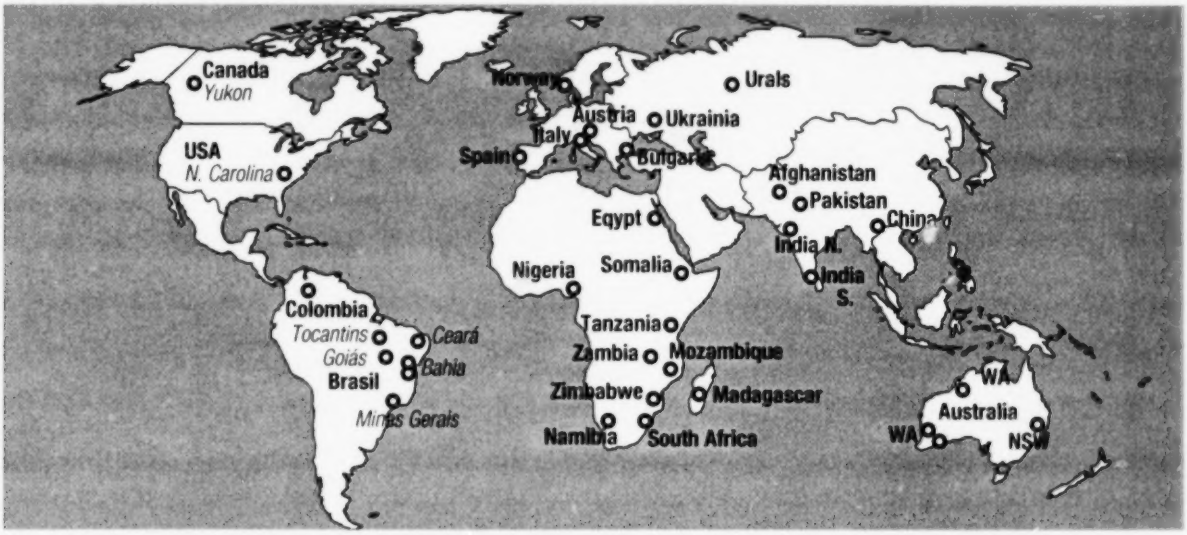


A rock from Area 51 containing many emerald crystals.

Regal Ridge (right of photo) with camp in front. (inset) Campsite.



Unless otherwise indicated, all emerald photos courtesy of True North Gems.

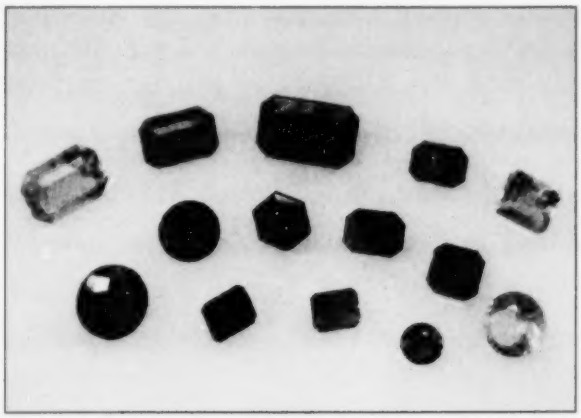


The world of emeralds in 2002. From "Emeralds of the world. extraLapis English No. 2: The legendary green beryl."

Lustrous facts about emeralds

- Emerald green is the most beautiful, deepest and brilliant colour imaginable. It is called the colour of life, beauty and eternal love.
- An emerald of a deep vivid green with slight flaws will be of higher value than a flawless emerald of a paler colour.
- Rarely are emeralds flawless. If you look into an emerald, you may find a fissure, a crystal or perhaps a bubble.
- Unlike sapphires or rubies, emeralds are not heavy. If an emerald is on the ground or in a streambed, you can assume that you are close to its source.
- Emerald is the birthstone for May, the 35th wedding anniversary stone, and the zodiac birthstone of Cancer the Crab.
- Emeralds were collected by Cleopatra, worn by Incas and Aztecs, sought by Spanish explorers, and used as a currency for criminal activity and lucrative cartels.

A collection of rough emeralds.



A collection of cut emeralds from Regal Ridge. The largest stone is about 0.5 carats. The most highly valued of these stones is the rectangular one in the front row on the left.

The world of emeralds in 2002. From "Emeralds of the world. extraLapis English No. 2: The legendary green beryl."

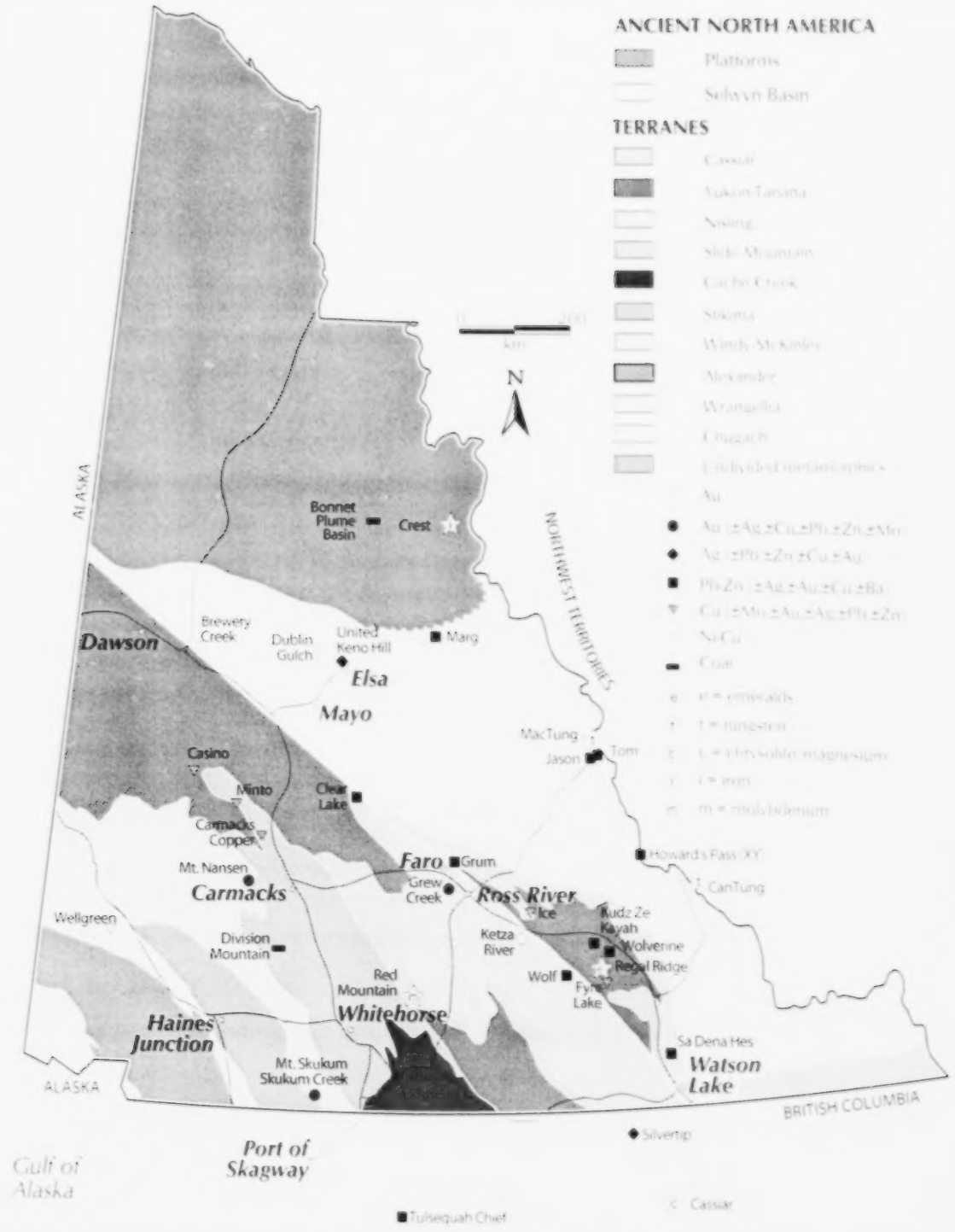
Lustrous facts about emeralds

- Emerald green is the most beautiful, deepest and brilliant colour imaginable. It is called the colour of life, beauty and eternal love.
- An emerald of a deep vivid green with slight flaws will be of higher value than a flawless emerald of a paler colour.
- Rarely are emeralds flawless. If you look into an emerald, you may find a fissure, a crystal or perhaps a bubble.
- Unlike sapphires or rubies, emeralds are not heavy. If an emerald is on the ground or in a streambed, you can assume that you are close to its source.
- Emerald is the birthstone for May, the 35th wedding anniversary stone, and the zodiac birthstone of Cancer the Crab.
- Emeralds were collected by Cleopatra, worn by Incas and Aztecs, sought by Spanish explorers, and used as a currency for criminal activity and lucrative cartels.

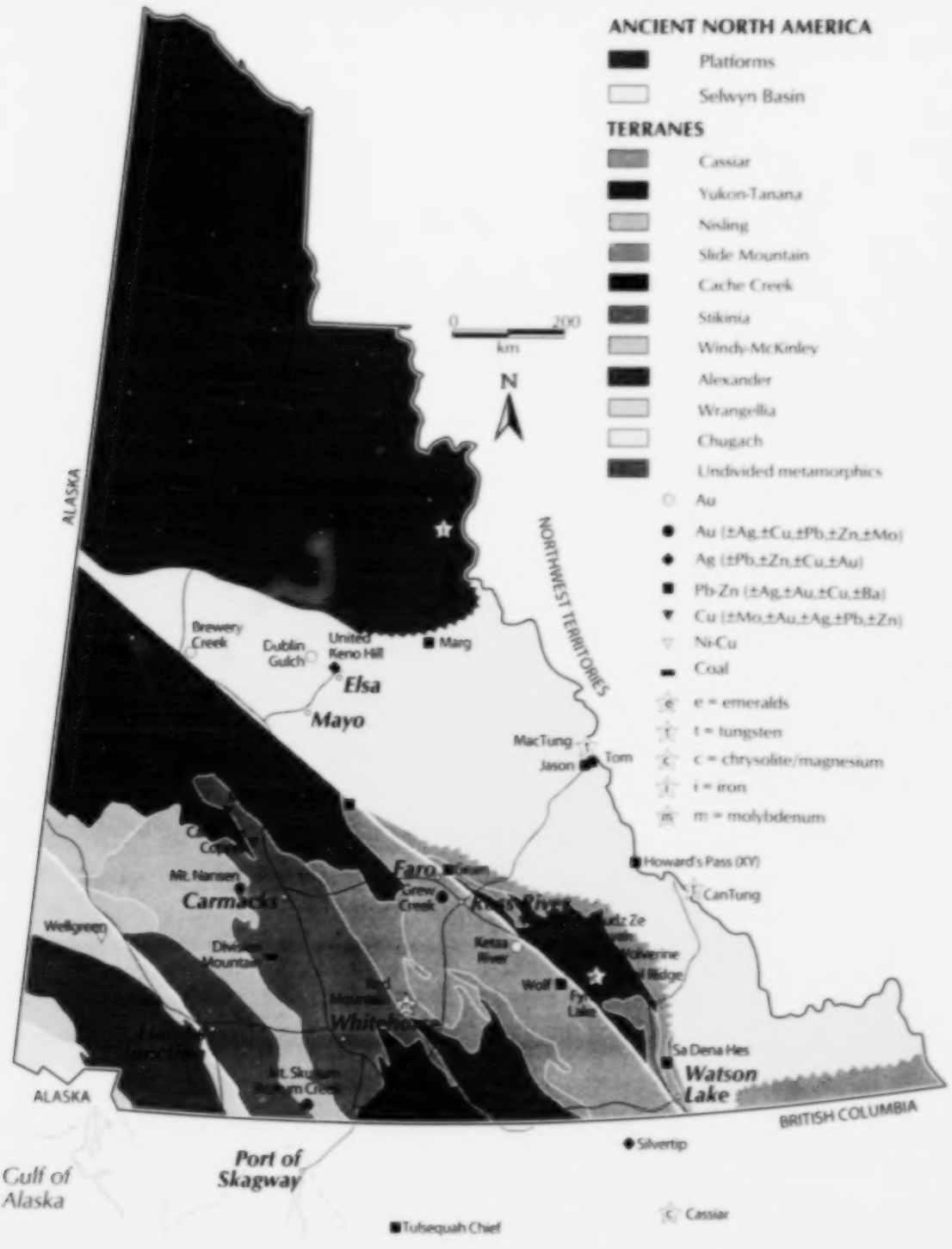
A collection of rough emeralds.

A collection of cut emeralds from Regal Ridge. The largest stone is about 0.5 carats. The most highly valued of these stones is the rectangular one in the front row on the left.

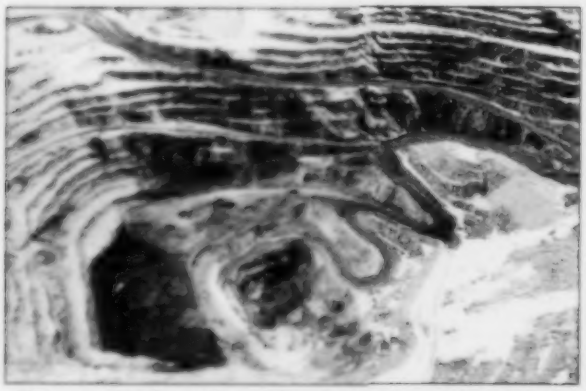
IMPORTANT HARDROCK MINING PROJECTS AND MINERAL DEPOSITS



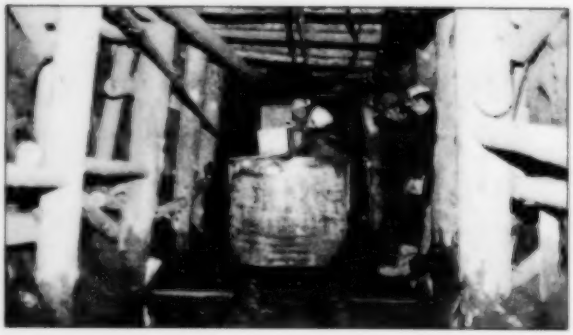
IMPORTANT HARDROCK MINING PROJECTS AND MINERAL DEPOSITS



SIGNIFICANT YUKON MINING ACTIVITY



Yukon government



Yukon government

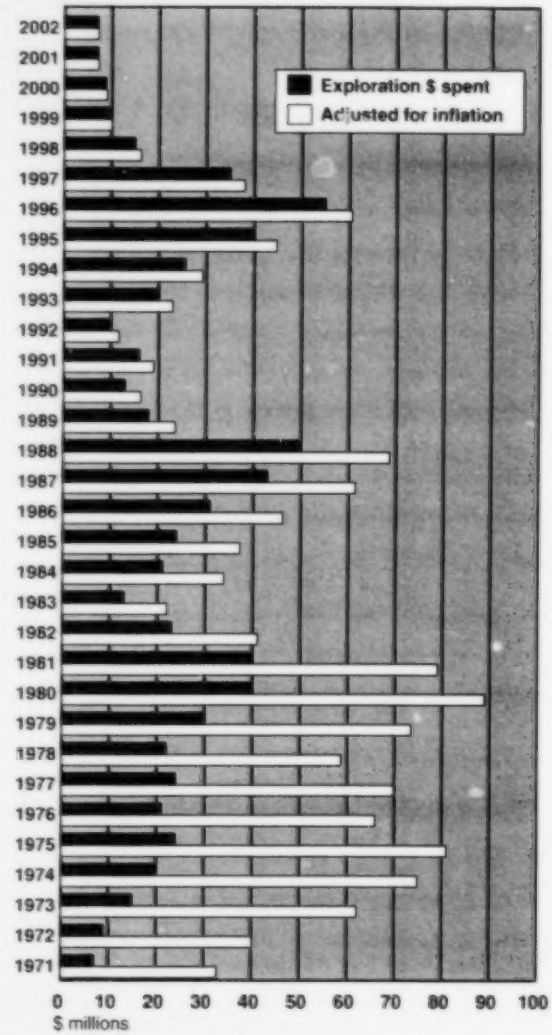
The open pit mine at Faro (above) and the underground mine at United Keno Hill mine in Elsa (right) have been significant in the mining history of the Yukon.

Significant Yukon mines since 1960

Name	Opening, closing	Main commodity
Brewery Creek*	1996-2001	gold
CanTung**	1962-1986	tungsten
	2002-ongoing	
Clinton Creek	1967-1978	asbestos
Faro	1969-1982	zinc, lead, silver
	1986-1993	
	1995-1996	
	1997-1998	
Ketza River	1988-1990	gold
Mount Nansen	1967-1969	gold, silver
	1975-1976	
	1997-1999	
Mount Skukum	1986-1988	gold, silver
Sa Dena Hes	1991-1992	zinc, lead
United Keno Hill	1921-1982	silver, lead, zinc
	1983-1989	
Venus	1906-1911	gold, silver
	1970-1971	
	1980-1982	
Wellgreen	1972-1973	nickel, copper
Whitehorse Copper	1967-1982	copper, silver, gold

*In 2001, Brewery Creek undertook heap leach operations only.
**CanTung is in the NWT but is supplied from Yukon communities.

Yukon exploration expenditures, 1971-2001



Sources: DIAND, Exploration and Geological Services Division

all photos this page, Yukon government

(top, left) Old Venus mine building on the South Klondike Highway, near Carcross. (top, right) Mine entrance, Mount Skukum, south of Whitehorse. (left) Tracks going into mine shaft at Mount Nansen, near Carmacks.

MINING: A WALK THROUGH THE STAGES

The complex process of finding ore bodies that can be mined at a profit is a difficult task which is often poorly understood. Establishing a producing mine is the result of a long process.

EXPLORATION

Over the last ten years, an average of $22.3 million was spent annually on exploration in the Yukon.

Exploration is distinct from mining. The detective work of exploration involves as much intuition as science. The process of discovering and evaluating mineral deposits requires constant decision making involving many intangibles.

Prospecting

Exploration starts with prospectors looking for rock with unusual amounts of metal-bearing minerals.

Successful prospecting involves much more than identifying minerals in the field. Good prospectors do their homework well before the season when they go out into the field. They study maps showing information about the glacial history, geology, geochemistry and geophysics of the areas in which they are planning to work. They visit a mining recorders' office to determine if the area is within First Nation land claims, or if it is already staked. Information from previously evaluated mineral claims helps prospectors choose where and how to work. Typically, ore bodies are found after claims have been worked several times by different owners.

The environmental impact due to prospecting is usually low to non-existent as crews and camps are small (one to five people) and travel is by foot, boat and occasionally helicopter or floatplane. These are low-budget and low-impact activities.

Yukon government

A geologist examines core samples, a critical step in exploration.

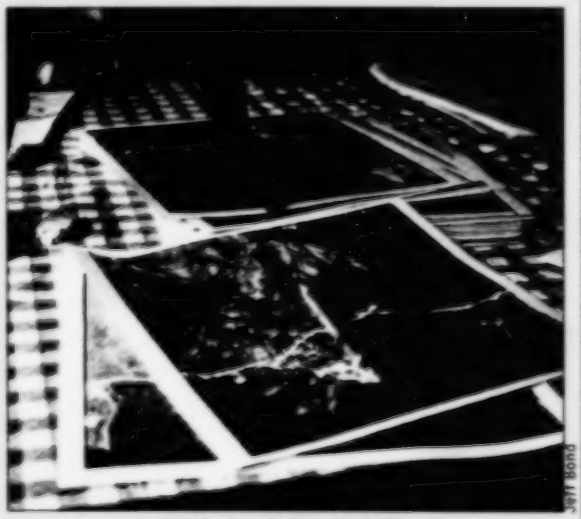
Resources to help prospectors start their investigation

Geochemical maps from the Geological Survey of Canada show the locations of stream silt samples that have been analysed for metal content. The Yukon Geological Survey geologists offer technical information, maps, reports and logistical advice.

The Yukon Geoscience Forum, the Yukon's annual mining information exchange, is an essential conference for most prospectors. Mining companies and government geologists give presentations at the forum on recent and on-going research, activities and findings.

Known Yukon mineral deposits are described in the Yukon MINFILE, which is available as a booklet, diskette or CD-ROM. This, and other geoscience information products, such as the annual Yukon Exploration and Geology publication, can be purchased at the Geoscience Information and Sales desk at the Whitehorse Mining Recorder office.

The Yukon government library in the Elijah Smith Building, in Whitehorse, carries a wide variety of publications on Yukon geology and mineral occurrences. Air photos are available for viewing. Air photos may be purchased from the National Air Photo Library in Ottawa.



Jeff Bond

Getting ready for the field: air photographs are one source of information.

Jeff Bond

Field office at a small exploration camp.

Staking

If prospectors or mining companies discover signs of mineral wealth, they may then choose to stake a mineral claim over their find. Staking a claim can be time-consuming and hard work. It is only necessary if they think they have a significant find, or they are worried about someone else staking it. Mineral claims are staked according to procedures defined in the *Quartz Mining Act*. After a claim is staked, the prospector or company records the claim at the mining recorders' office. Prospectors may spend a minimum of $100 per year in research, analysis, or field work to maintain each claim or, annually, they may pay a flat renewal fee of $100 per claim. They may also file annual assessment reports to government agencies on the work that they have done. If these conditions are not met, the claims lapse and the assessment reports become public information.

The activities required to maintain a claim need only occur on a small section of the staked land. Therefore, in any given year, only a small percentage of the total land area staked in the Yukon may benefit from geological work or prospecting.

In 2001, 1.9 per cent of the total Yukon land base was listed as registered under the provisions of the *Quartz Mining Act*.

Extensive exploration is usually necessary to evaluate a promising mineral occurrence. Hand or machinery trenching down to bedrock and drilling are required to reveal more information about the type, size and grade of the deposit. Airborne geophysical surveys are sometimes useful to find or outline mineral deposits without anyone setting foot on the ground.

How do prospectors make money?

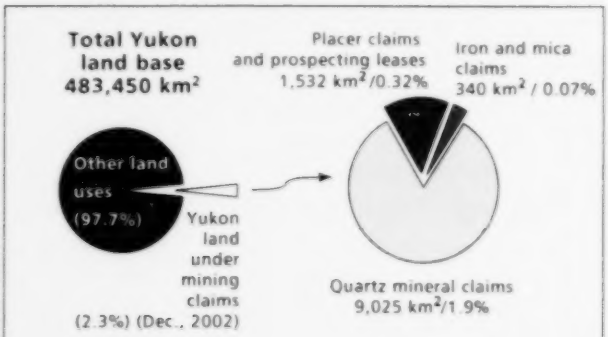
Prospectors focus on "grassroots" exploration. They cover large areas and find promising indicators. Generally, they have limited funding and cannot completely assess a mineral property.

In most cases, prospectors need to raise money to look for mineral deposits. Often, prospectors will turn to a junior or senior mining company and "option" a promising mineral property to the company. The option agreement allows the company to earn an interest in the project by doing work on the property and making option payments to the original claim holder, the prospector. The prospector may also earn revenue by selling the rights to further explore an interesting property, or to mine a deposit.

Only a small fraction of all mineral occurrences examined ever become a mine. Since 1898, two per cent of all mineral occurrences investigated in the Yukon have resulted in the development of a "producer" ranging in size from the large Faro lead-zinc mine to small producers of jade.

Most claims change hands many times before a mine is established. It can take at least three companies and many years of exploration to discover and develop a mine in the Yukon. Fifty million dollars may have been spent by this time. Despite the large amount of money spent on exploration, the chances of finding a mineable deposit are low.

YUKON LAND UNDER MINING CLAIMS


Total Yukon land base 483,450 km²
Placer claims and prospecting leases 1,532 km²/0.32%
Iron and mica claims 340 km² / 0.07%
Other land uses (97.7%)
Yukon land under mining claims (2.3%) (Dec., 2002)
Quartz mineral claims 9,025 km²/1.9%

Yukon Bureau of Statistics

Note: Staked claims are not necessarily being actively explored.

Exploration is carried out by individual prospectors and mining companies. Senior or large mining companies with income from producing mines may fund exploration. In-house junior or smaller mining companies are in the business of exploration only. Junior companies finance their year-to-year operations by selling shares on stock exchanges, such as the Canadian Ventures Exchange. This kind of stock exchange recognizes both the high risk of exploration and the high reward if a mine is found.

FEASIBILITY STUDIES AND PERMITTING

After a significant ore reserve has been discovered and evaluated, a detailed feasibility study will be carried out to determine if the property can be profitably mined. The size of the operation, its life expectancy, method of mining, development plan, capital and operating costs, financing, and energy sources are some of the considerations examined in this feasibility study.

The costs required to get a mine up and running are high. Raising this money is often a critical factor. Like any other business, a mine must make a profit and show sufficient return on the investment for its shareholders.

The regulatory permitting process, which includes an assessment of environmental impacts, is also carried out by the company at this time.

A decision to mine or not is made at an early point in the feasibility study. This will be based on both economic considerations and the progress of environmental impact studies. Metal prices are significant factors in this decision, yet extremely difficult to predict. Potential mines do not open, and producing mines close down, if the price of their product goes below a certain level. If there is a decision to go ahead, more detailed feasibility studies will be carried out and the application for a water licence will be made.

An extensive drill program can be carried out to determine the extent and grade of a deposit and allow an ore reserve calculation. This determines, in part, the economic feasibility of mining that deposit.

Diamond drills, which can drill to several thousand feet, produce cores of rock that can be analysed to determine mineral content. Drilling is expensive, so drill targets are chosen carefully.

Rod Hill

Working on a diamond drill.

CONSTRUCTION AND PRODUCTION

Upon receiving a water licence, the construction of the mine infrastructure will begin. A final production decision will be made during the construction phase.

RECLAMATION AND CLOSURE

When the ore body is exhausted, the buildings and equipment are removed. Reclamation is completed to encourage the area to return to a natural state.

There have been many changes in the regulations dealing with the environmental impact of mining in the Yukon. Companies must now provide plans and insurance that ensure reclamation work and mine closure will take place in a satisfactory manner.

In the Yukon, as in the rest of Canada, mines that have gone into production during the last five to ten years have undertaken extensive research into reclamation and incorporated their reclamation objectives into their daily operations. With an abandonment plan in mind from the start, tailings, overburden and structures are dealt with in such a way that their final disposition is feasible and affordable. It makes sense for the environment, and it makes a lot of sense financially.

The reclamation of mines that opened before current regulations were established is a difficult and expensive process, as is the case with many other past land uses. New regulations, and an overall expectation from the Canadian public, stress the importance of sound environmental management in the resource-based industries.

The industry is responding and changing. Canada is becoming a leader in reclamation technology and methods, bioremediation and environmental research.

STAGES OF MINING

PERMITTING PROCESS STAGES		YUKON PROJECTS
	REGIONAL EXPLORATION • Prospecting • Regional surveys	Finlayson Lake area McQuesten Intrusive Belt (Mayo to Dawson City area) Dawson Range Cu/Au Belt
	PRELIMINARY EXPLORATION • Discovery of mineralization • Delineation of mineral zone • Magnitude of deposit	Regal Ridge Wolf Clear Lake Grew Creek Hyland Gold
Environmental baseline studies	**ADVANCED EXPLORATION** • Diamond drilling • Trenching	Marg Ice Red Mountain MacTung Division Mountain Fyre Lake
Permitting process begins Company submits project overview Company submits Initial Environmental Evaluation (IEE)	**PRELIMINARY FEASIBILITY STUDY** • Ore reserves • Scale of operation • Development plan • Capital costs • Operating costs • Cash flow • Net present value	Ketza River Mount Skukum/Skukum Creek Wellgreen Crest Howard's Pass Fyre Lake MacMillan Pass – Tom, Jason Casino Kudz Ze Kayah/Wolverine
	TEST MINING PROGRAM • Obtain bulk sample • Test ore continuity • Identify mining problems	Silvertip, B.C. Dublin Gulch Carmacks Copper Sa Dena Hes Tulsequah Chief
Water licence application	**FINAL FEASIBILITY STUDY** • Similar to preliminary but more detailed • Budget for operating and capital costs • Cash flow projection	
Water licence received	**CONSTRUCT MINE, MILL AND PLANT**	United Keno Hill Minto
	PRODUCTION	CanTung
	RECLAMATION	Brewery Creek

Yukon government

Tailings from historic operation near Dawson City.

Ken Galambos

Prospector with rock sample.

PLACER MINING: GOLD IN THE WASH

The term "placer" is a Spanish word, meaning "a place where gold can be recovered from gravel." As this suggests, placer mining is the technique of recovering gold from gravel. Throughout history, it has been practised around the world. The story of Homer and the Golden Fleece refers to the sheepskins used in Asia to collect gold; a method of placer mining. The heavier gold was caught in the fleece.

Placer deposits occur in several areas in the Yukon, though historically, most of the mining has taken place near Dawson City. This area is particularly favourable for placer deposits because it is in the unglaciated part of the Yukon.

Most of the southern Yukon and large parts of the rest of North America were once covered by glaciers. Glaciers tend to rework and dilute placer gold deposits by mixing gold-bearing gravel with large amounts of other sediments. However, during the last ice-age, the Dawson City area was not covered by glaciers. This left rich gold deposits along Bonanza and Eldorado creeks. This area was later known as the Klondike goldfield. Approximately 80 per cent of the Yukon's placer gold is currently mined from the Klondike and other unglaciated parts of the territory.

THE HEART OF DAWSON CITY'S ECONOMY

Placer mining is particularly important to the economy of Dawson City. According to a 1994 Yukon government study, mining contributed 5,226 person-months of employment per year, more than any other Dawson City industry at that time. The total income earned by placer mining was just under $22 million. The 1994 study also concluded that placer mining provided the greatest economic spin-offs to service businesses in the Dawson City area. This was attributed to the following factors: higher incomes, longer working hours, the influx of non-resident miners and their families, and the capital-intensive nature of mining and

William LeBarge

Placer operation in the Klondike area. Settling ponds are visible in the foreground. Dark grassy areas were worked the previous year and are quickly revegetating.

local purchases. Placer mining requires large amounts of fuel as well as parts for equipment maintenance. These purchases made up 75 per cent of the total operational spending by placer mining.

In 2002, the number of placer mines and the value of gold production decreased significantly from 2001. A total of 400 people were employed at 115 placer mines. Gold production was 66,353 crude ounces compared with 70,819 crude ounces for 2001 and the gold production dollar value was C$26 million compared with C$23 million in 1999.

Placer gold is getting more difficult to find as reserves in traditional placer mining areas decline. By expanding knowledge of placer gold deposits and applying it to other areas, new sources of placer gold may be discovered in different geological settings.

FORMATION OF PLACER DEPOSITS

Placer deposits consist of loose material (gravel, sand and clay) formed by the weathering of mineralized bedrock. As the bedrock breaks down, heavy minerals like gold, silver, platinum, tin, copper, tungsten and some gemstones are released. These minerals become concentrated on the bottom of creeks and form a pay streak.

C. Mougeot

Permafrost is a special consideration for mining projects. Pictured here is a placer cut near Dawson City.

• F U N • G O L D • F A C T S •

"Au" the chemical symbol for gold, from the Latin "aurum" meaning "shining dawn." Aurora was the roman goddess of dawn.

The total amount of gold mined in the world since 3900 BC would fit into an 18 x 18 x 18 metre cube.

Chryso is the Greek word for gold.

In English, a "crysophile" is a lover of gold.

An ounce (31.1 g) of gold can be stretched into a wire 100 km long.

Gold can be hammered so thin that a cup of it could be flattened over an entire football field.

1,000 sheets of gold leaf equal the thickness of a human hair.

The rarest form of gold is a nugget. The largest known nugget is called the Welcome Stranger. It weighs about 70.8 kg. It was accidentally uncovered, from just below the surface of the ground, by a wagon wheel in Victoria, Australia, in 1869.

South Africa is the world's leading supplier of gold.

Gold reached an all-time high price of US$800 per ounce in 1980.

An authentic gold nugget is considered a gemstone because of its rarity and beauty.

Even though gold is rare, it is far easier to find than to win a major lottery.

There are about 10 billion tons of gold in the world's oceans; however, there is yet no known way to economically recover it.

from: www.goldfever.org

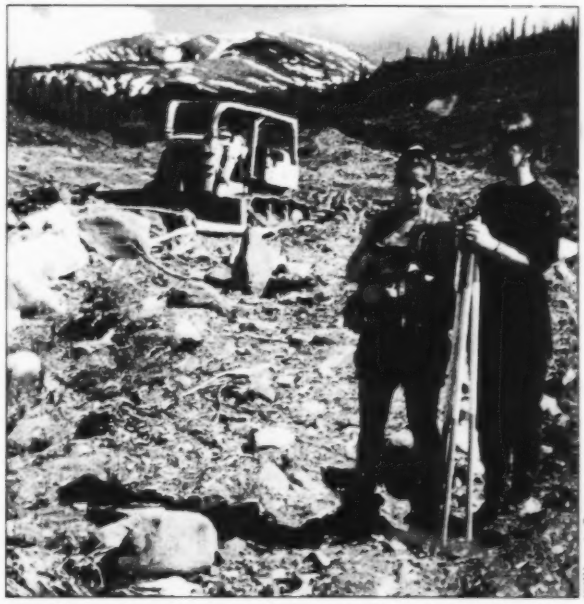
FARMING THE GOLDFIELDS

"The placer mine is the family farm of the north," says miner Mike McDougall. Many of the farm folk from the Canadian prairies find their way to the goldfields of the far northwest. He lists a number of parallels between growing grain under the expansive skies of the prairies and sluicing for gold in the forested valleys of the Yukon.

The working environments and lifestyles are similar. In both cases, people work in isolated settings with their nearest neighbours several kilometres away. The "growing season" is short. Placer miners usually sluice from June to mid-September when the water and ground are not frozen.

Like farmers, placer miners need to work long and hard days, with few holidays, to make their money within this narrow window of time. In some years, the crop is better than others. Like agriculture, the "crop" is an internationally traded commodity and the "grower" has no control over the price.

Skills and a working style learned on the family farm are essential in the placer mining business. Self-reliance is key. The successful operator must not only be able to run heavy equipment but to fix it as well.



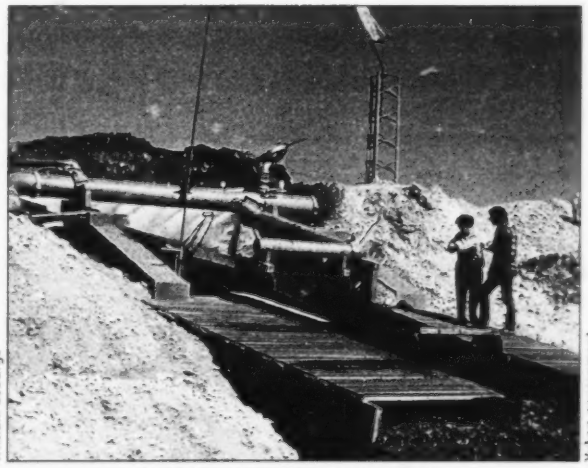
William LeBarge

Families and students are often part of the placer operation.

Veteran placer miner, Norm Ross, confirms that a lot of farm kids from Saskatchewan and Alberta gravitate to the goldfields of the Yukon. They come largely through word of mouth.

William LeBarge

Small crews make the best of the long days to fit in all the work before fall.



Yukon government

A sluice at Norm Ross' placer site.

TOOLS OF THE PLACER MINER: Gold pan and water

Jeff Bond

Ken Galambos

The GOLD PAN is used to test prospective gravels for gold.

Jeff Bond

WATER is usually used as the transporting or washing agent to remove the gold from the sand and gravel. The water is often pumped from a stream into an elaborate system of pumps and settling ponds. Later it is returned to the stream once the fine sediments have settled.

TOOLS OF THE PLACER MINER: Sluicebox

After stripping the vegetation, topsoil and overburden, gold-bearing gravel is excavated, screened and washed through a SLUICEBOX. Lighter minerals such as silt and clay flow through while gold and other heavy minerals settle in the sluicebox. Some of these other minerals are magnetic and can be separated from the gold by a magnet. The end products are gold concentrate and tailings.

A sluicebox can vary substantially in size and design.

Yukon Contaminants Curriculum, Northern Contaminants Program

William LeBarge

Gold-rich gravel is dumped into a sorting box. Larger rocks come out in a pile and the finer particles run through a sluicebox.

Rod Mill

Working the sluicebox, an essential part of the processing of placer gravel.

PORTRAIT OF AN ENGINEER...RANDY CLARKSON

Randy Clarkson is a Yukon mining engineer with a passion for travel. At the request of the Klondike Placer Miners' Association in 1988, Randy tested the efficiency of gold recovery from Yukon placer operations and worked on improving mining and reclamation practises. He fed tiny samples of irradiated gold into the head of a sluicebox. Using a scintillometer, he could accurately measure how much gold was recovered at the end of the sluicing process. If all the gold was not recovered, a recovery estimate was calculated and improvements to the sluice box were made.

This expertise then took Randy to remote areas of Guyana. Randy was hired by CIDA (Canadian International Development Agency) and Canmet, a division of Natural Resources Canada.

My job was to go into the hinterland to show local miners how to recover gold in the primary stages. We used sluice boxes refitted with the latest Canadian technology (developed in the Yukon), then helped them (Guyanese) minimise the use of mercury in a closed circuit. Not only did this cut down on the release of mercury into the environment and reduce occupational hazards of mercury poisoning to the workers themselves, but it reduced cost to the miners because they could recycle the mercury.

His observations of their mining practices were like a journey back in time to the Klondike Goldfields of 1898.

A sluice box was made with a chainsaw and a piece of dirty string. The miners would fall a tree, mark up the lumber into planks, cut it to within 1/16 of an inch and build a sluice box.

The hopes, dreams and stories of present-day Guyanese miners are also similar to those of the cheechakos arriving in the Yukon over one hundred years ago.

The people are very poor with very little to lose. They go into the outback to face great dangers in the hope of striking it rich. These prospectors are called 'pork knockers' because they take 5 lbs. of salt pork, 10 lbs. of rice, a bottle of mercury and a gold pan into the jungle for months. When they strike it rich, they'll go into Georgetown (capital of Guyana) with good intentions of sending money to their families. Often this doesn't happen as there's always bars, brothels and gambling opportunities. They never make it past these and have to go back out into the bush.

The Guyanese would walk four and five hours, often barefoot, to learn what Randy had to offer. They left with new knowledge in technology and environmental practises learned and tried in Yukon goldfields.

I would refit the sluicebox with expanding metal, angle iron and all sorts of different things. I was able to show the Guyanese how to get concentrate using water, riffles and matting, without the use of mercury. They were able to make pure gold using small amounts of mercury. We recycled that mercury using simple cloth filters to squeeze out excess mercury (like a sponge). We then heated that excess and collected condensed mercury vapours. It's kind of like a still.

The skills Randy passed on to the grubstake miners in Guyana will help improve their own health, mining practices, and the environment.

Randy Clarkson

Randy Clarkson demonstrating a sluice box to the Prime Minister of Guyana, the CIDA representative, the Executive Director of the Gold and Diamond Miners' Association, the Canadian High Commissioner and local Guyanese.

MINING RESPONSIBLY: THE TIMES ARE CHANGING

At the beginning of the 21st century, the emerging mining industry is very different from that of even a decade ago. Environmental responsibility extends to all phases of the mining process, including exploration.

Exploration is carried out over extensive areas, yet less than 2 per cent of the Yukon land base may actually be staked. Often, many of those claims have no work done. Active mines occupy an even smaller area, less than 0.1 per cent of the Yukon land base.

Increased environmental awareness and improved technology have led many exploration companies to change their operations independently of government regulations.

There are more opportunities for community input through increased consultation and co-operative research ventures. Changes in legislation have significantly impacted reclamation practices in placer and hardrock mining.

Yukon government

Mining exploration site in the North Canol valley. Most mining camps now have "no-hunting" and "no-fishing" rules.

TECHNOLOGICAL IMPROVEMENTS

Technological improvements include larger helicopters and smaller diamond drilling equipment. Until the late 1960s, diamond drills could not be moved by air. Instead, they were dragged through the landscape, creating bulldozer access roads.

Now, with larger helicopters and lighter drill equipment, the "footprint" left behind from drilling has gone from hundreds of hectares (the whole length of a road) to a few square metres. The risks of erosion are significantly reduced.

Another positive technological change involves the use of excavators instead of bulldozers for trenching. New small excavators offer many advantages over bulldozers. When trenching with a bulldozer, material must be pushed downhill and out of the trench, which is as wide as the blade of the bulldozer. However, the small bucket of the excavator can make a much narrower cut. It can remove and set aside the topsoil and organic material, then dig deeper and pile the overburden (other soil and rocks) on the opposite side of the trench. When the trenching is complete, the different materials can be placed back in their original location. The area of disturbance is not much wider than the one metre width of the bucket, and the area will revegetate quickly because organic matter and roots are placed back at the surface.

The excavators have much lower bearing pressure than bulldozers and do not destroy as much vegetation. They can be dismantled and flown into remote exploration sites by helicopter, eliminating the need for access roads.

Diamond drillers are now much more careful about the drilling products they use. There is an effort to use drill mud with biodegradable additives rather than those that are petroleum-based.

Yukon exploration companies are also conscious of wildlife. If there is an area where sheep are lambing in early summer, it is left alone until later in the season. The same considerations are given during the fall caribou rut. Garbage is burned every night or taken out. Camps are moved by helicopter. Pilots are given strict instructions to avoid wildlife. Many camps prohibit hunting and fishing.

The growing use of Global Positioning System (GPS) units for surveying also reduces the disruptions on the ground. These small portable devices use satellite signals to provide a geographical position. This allows for more accurate locating of drilling sites and the need for fewer survey markers in the ground.

INCREASED COMMUNITY CONSULTATION

Exploration companies are consulting more with First Nations, communities, outfitters and other user groups to minimize or avoid conflicts wherever possible.

Industry, governments and First Nations are gaining a better understanding of each others' needs and concerns by forming partnerships and working together. It is important for companies operating in the Yukon to work with First Nation governments to ensure that the economic benefits of mineral development are shared. As well, partnerships make it possible for exploration and other industrial activities to occur in conjunction with traditional land use such as hunting, fishing and berrypicking.

There are 14 First Nations in the Yukon. Under the Umbrella Final Agreement, eight self-government agreements have been signed and negotiations continue. The resolution of

Rod Hill

Whenever possible, smaller and lighter excavators are used to sample a placer deposit.

land claims provides clarity and certainty for resource development. Land claims agreements encompass a broad range of topics: specialized training, scholarships, contracting opportunities, protection of traditional lifestyles and the environment.

Successful working relationships between a First Nation and a mining company have none-the-less occurred prior to the resolution of land claims. The following are some examples of joint ventures:

- The Tr'ondëk Hwëch'in Development Corporation, a First Nation company, built the access road to Viceroy Resource Corporation's Brewery Creek mine.
- The Ross River Dena Development Corporation was very involved in the mining sector at the Anvil Range mine in Faro and in the development of the Wolverine deposit.
- The Selkirk First Nation may see the first mining development on settlement lands in Canada. Minto Explorations Ltd. plans to develop a copper mine west of the Yukon River from Minto Landing. A socio-economic agreement with the First Nation will provide employment and business opportunities at the mine.

CURRENT LEGISLATION

As we have seen, there are a number of key pieces of legislation that directly apply to the mining industry in the Yukon. On April 1, 2003, the Yukon government became responsible for managing forests, minerals, water and land resources on all public lands in the territory. Existing federal and resource laws have been "mirrored" by territorial laws. The main difference is that these laws refer to territorial institutions instead of federal

CO-OPERATIVE RESEARCH VENTURES
The Mining Environment Research Group

The Mining Environment Research Group (MERG) is a co-operative working group established in 1998. It is made up of government agencies, mining companies, Yukon First Nations and non-government organizations to promote research into mining and environmental issues in the Yukon.

A summary of the research results commissioned by MERG is provided in non-technical language. This can then be used by a broad audience, including the general public, First Nations and communities.

MERG members work co-operatively in several areas:

- gathering information specific to the Yukon natural environment,
- identifying practises in mining activities to reduce adverse environmental effects,
- encouraging research to identify solutions to potential problems before there are negative environmental effects,
- providing the opportunity for exchange of information to benefit Yukoners and companies doing business here, and
- increasing confidence in environmental predictions for the opening, operation and closure of mining facilities in the Yukon.

Reports are available for viewing on the Energy, Mines and Resources web site (www.emr.gov.yk.ca) and in all Yukon libraries. They are also available for purchase at the Map Publications desk, 667-5200.

Highlights of projects

- *Yukon placer deposits and water quality sampling program.*
- *Experimental reclamation project: establishment of shrub trial plots at Brewery Creek.*
- *Information brochure on cyanide.*
- *Assessment of low permeability covers as infiltration and oxygen barriers to reduce acid generation in mine tailings in the Yukon.*
- *Natural attenuation of heavy metals in shallow subsurface soils over permafrost downslope of Galkeno 300 Adit, United Keno Hill Mine.*
- *Experimental reclamation project: shrub trial plots at Brewery Creek mine.*
- *Experimental trials for restoring disturbed sites in permafrost areas using bio-engineering techniques.*
- *Monitoring low permeability cover performance.*
- *Arsenic in plants important to two Yukon First Nations: impacts of gold mining and reclamation practices.*
- *Flying in sheep country: How to minimize disturbance from aircraft.*

ones. These will be used until the Yukon develops and implements its own legislation.

The following acts and regulations guide mineral activities in the Yukon:

- *Placer Mining Act* and Placer Mining Land Use Regulation
- *Quartz Mining Act* and Quartz Mining Land Use Regulation
- *Territorial Lands (Yukon) Act* including Land Use Regulation, Coal Regulation and Dredging Regulation
- *Waters Act* and Waters Regulation

The federal *Fisheries Act* and First Nations Final and Self-government Agreements also apply to mine development projects.

Additional sets of acts or regulations may apply to the mining process, depending on the size and type of mine planned. A list of the acts and regulations, with brief descriptions, is found in Appendix A.

PLACER MINING IN THE NEW MILLENNIUM

Increased environmental awareness has challenged the placer mining industry in the Yukon to meet ever better environmental standards.

Placer mining in the Yukon is now regulated by a dual permit process: a water licence and a mining land use permit.

Water licences

Water licences are issued by the Yukon Water Board, and they serve the following purposes:

- set the allowable sediment discharge,
- limit the maximum rate of water use,
- restrict the type of mining in or adjacent to streams,
- require the settling or removal of suspended sediment in discharge water, and
- require the stabilization of tailings and stream channels.

Miners must provide detailed plans for diversions, drains, and the construction of settling ponds.

In order to manage streams and determine allowable discharges under the Yukon Placer Authorization, streams are classified into five types based on their sensitivity to water quality and their fish producing capability. (See chart below.)

When more than one mine is on a stream which requires protection, each of the mines has a lower allowable discharge standard. This ensures that their cumulative effect does not exceed the acceptable total sediment concentration.

Both the construction of new stream channels and the restoration of disturbed ones must meet specific guidelines to ensure that the new channels are stable during and after mining. Miners are encouraged to consider mining plans that do not involve disturbing existing streams. In current placer mining, there are many miners who are working on bench claims or in wide valleys away from the creek. They do not need to alter or divert the natural watercourse. Many of these operations

Stream classification

Class	Description	Management
I	sustain spawning and incubation of salmon, trout and char populations	requires habitat compensation for the disruption of important fish habitat before mining commences
II	may support rearing salmon, trout and char	
III	support other freshwater species, but are not associated with salmonoids	
IV	support past or present mining and are not seen to be important for the maintenance of fish populations	requires restoration of fish habitat
IVA	have fish (non-salmonoid)	
IVB	do not have fish	
V	unclassified (over 95% of Yukon streams). Little is known about their fish populations or placer mining potential.	must be assessed and classified to determine the level of habitat protection required before a mine can operate on it

have little or no discharge, and they recycle their processing water and remove sediment before re-use.

Mining land use permits

The objective of reclamation is to leave the land in the same condition of comparable utility for wildlife or humans as it was prior to disturbance, and where revegetation will occur naturally and rapidly.

Evolving regulations

- late 1960s: Release of fine sediment from placer mines into adjacent creeks identified as an environmental concern.
- 1970: Discharge from placer mining first monitored after the establishment of the Yukon Water Board (YWB).
- 1986: Government and industry began developing regulations to protect fish and fish habitat, while giving the industry certainty in the form of clear guidelines to work within.
- 1988: Yukon Fisheries Protection Authorization (YFPA) established.
- 1993: Yukon Placer Authorization (YPA) established. The YPA is based on scientific principles to protect fish from the negative effects of placer sediment, and provide for the protection, compensation, restoration and alteration of fish habitat. YPA was also designed to meet the resource management requirements of the *Canadian Environmental Assessment Act* (CEAA) and the Final Umbrella Agreement of Yukon First Nations. Under YPA, placer miners are required to apply for a water licence from the Yukon Water Board.
- 1999: Yukon Placer Mining Land Use Regulations (MLUR) came into effect to provide environmental screening and formal reclamation standards for all exploration and mining land use activities on placer claims and leases, including activities that may not require water licences.
- 2003: A review of YPA was completed in 2002; however, Fisheries and Oceans Canada decided to replace the YPA. Fisheries and Oceans Canada, Council of Yukon First Nations and the Yukon government will work on developing new rules to be implemented by 2007.

The Placer Mining Land Use Regulation (MLUR) under the *Placer Mining Act* has formalized reclamation standards for all exploration and mining activities on placer claims and leases. All placer mining land use activities undergo environmental screening and receive comments from stakeholders prior to approval.

Guidelines are provided in MLUR for the following aspects of reclamation: re-contouring hillsides and banks, preventing long-term erosion, allowing for the re-establishment of the vegetative mat to prevent slumping and subsidence, and removing garbage and waste.

Placer exploration and mining activities are divided into four classes, based on increasing potential to have adverse effects on the environment. Classes consider the following criteria: area of overburden to be disturbed, volume of trenching, length of road or lines constructed, number of person-days per camp, and amount of fuel storage.

Tara Christie

This lake was created in 1991 by miners as part of the reclamation work. Moose frequent it to eat the weeds.

A project with a greater potential for adverse effects on the environment is considered under a higher class and receives more rigorous environmental screening.

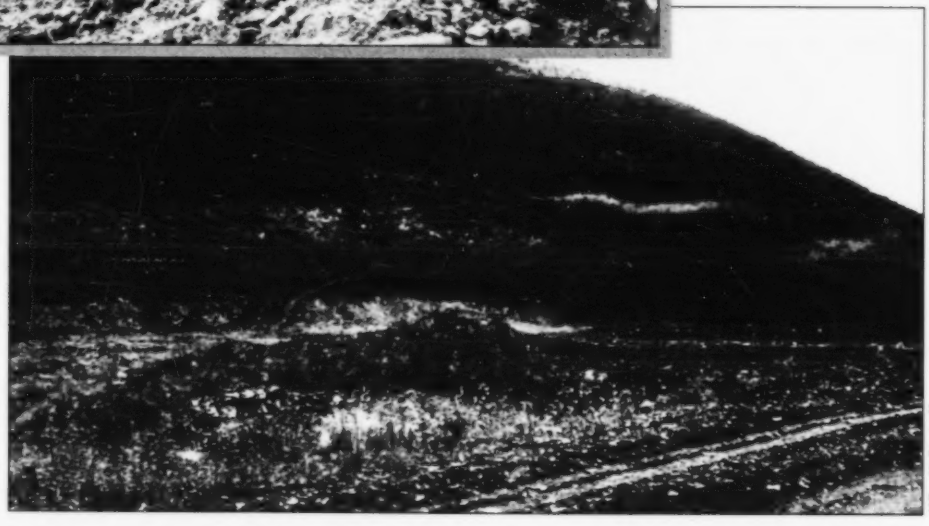
The most important component of this new permitting process is planning. Operators can no longer leave reclamation of the land until the final stages of mining. In order for a placer mine to continue operation, mining inspectors from the Yukon government must see on-going efforts at reclamation in accordance with the mining plan. The inspectors must also confirm that reclamation has been completed before the final abandonment of a property. On-going reclamation is more affordable and feasible. Well thought-out operating plans provide good protection for the environment and sound financial planning for placer miners.

Some placer miners have shown their commitment to the environment by the clean-up of garbage and scrap metal that has been abandoned by previous mining operations or residents.

Revegetation takes place rapidly in most placer-mined areas, particularly on old ponds, fine tailings and re-contoured overburden. Within one to two years, native plants and grasses usually form an initial ground cover on fine-grained surfaces.

Mike McDougall

Placer mining in the Sixtymile area; stripping in ice-rich permafrost soils, April, 1996.



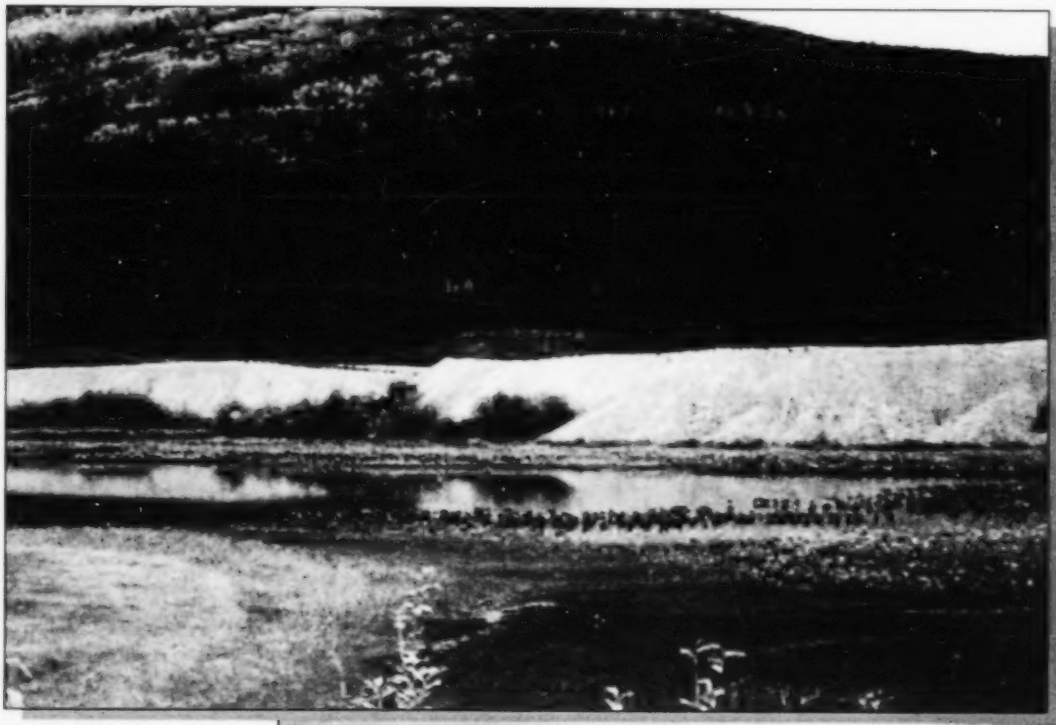
Mike McDougall

Same site, after reclamation, August, 1999.

Various types of willows are often the next shrub to grow in previously mined areas. These species provide a stabilized surface, prevent erosion and provide cover for wildlife within a very short period.

Depressions such as old ponds, reservoirs or reclaimed mining cuts often fill with water providing wetlands for ducks and migratory birds. Huge flocks of sandhill cranes on their migration south have been noted to rest and overnight on settling ponds and placer tailings.

The tender willows found in mining areas and tailings ponds are favoured locations for browsing moose.



Tara Christie

Tara Christie

These sandhill cranes flew overhead in the fall of 1999. They landed on settling ponds, reclaimed ponds and frozen tailings piles over at least a four-kilometre reach of the Lower Dominion Creek, near Dawson City (from the confluence of Gold Run to the confluence of Eureka).

MADE IN THE YUKON

The current regulatory regime to monitor land use and discharge by placer mining has been designed as a "made and administered in the Yukon" solution to meet the requirements for environmental screening and monitoring of mining under the *Environmental Assessment Act* (EAA) and the *Yukon Environmental and Socio-economic Assessment Act* (YESAA). Compliance with all regulations for placer mining is enforced by the Yukon government's placer inspectors. If you want to know more, please contact the Yukon government (Mining Lands) or the Yukon Water Board.

Mike McDougall

Mike McDougall

Bench during hydraulic stripping in 1986.
(inset) ***Same area in August 1991, five years after revegetation.***

RECLAMATION

Division Mountain property

"When you design an exploration program with the idea of reclamation in mind, it is not as physically difficult or as expensive as you would think," said Rob Carne, an exploration geologist with 28 years of experience in the Yukon. Carne is a partner with Archer Cathro and Associates, an exploration consulting company which has operated in the Yukon for 35 years.

Carne is also the president of Cash Resources Ltd. He is in a good position to speak about the expense of reclamation on exploration projects. Cash Resources owns the Division Mountain property located about 90 kilometres northwest of Whitehorse. The property is estimated to contain 52.9 million tonnes of near surface, low sulphur thermal coal. Cash Resources worked on the project from 1992 to 1998.

If reclamation is not part of the exploration and planning process, it can be very expensive and difficult. From the beginning, the exploration program at Division Mountain was designed with reclamation in mind. "You can design your program to minimize the impact and the reclamation that will be required," said Carne.

Before Cash Resources built roads over areas underlain by permafrost, all the trees were cut with a chainsaw at ground level and removed. Every effort was made to preserve the ground cover vegetation so it would insulate the permafrost. "We have been driving on this road with pick-up trucks for three summers now and the permafrost is still there," said Carne, "because we took every care not to disturb the insulating moss mat."

In the case of temporary roads not underlain by permafrost, an excavator was used to put the moss, trees and shrubs back over the surface. This sheltered new grass, encouraged its growth and prevented access.

In another situation, trenches were dug on drier ground during the summer to find coal seams which tended to be located under two to three metres of glacial till.

"Carried out in conjunction with exploration, reclamation should add no more than five per cent to your budget," said Carne. "It makes sense financially, and it significantly reduces short-term and long-term impacts of exploration projects."

What about coal?

Seven sedimentary basins which host coal deposits have been identified but there has been limited exploration in many areas and reserve potential is unknown.

Large tonnage potential has been identified in the Bonnet Plume area in northeastern Yukon.

There has been growing interest in thermal coal at Division Mountain, a Cash Resources project near Whitehorse, where the capacity for significant tonnage was recently recognized. This deposit has the potential to fuel a growing local industrial power demand and meet the requirements of Asian markets.

Jeff Bond

Working to keep the land as undisturbed as possible.

MINING RESPONSIBLY

As society has become more environmentally aware, so has the mining industry

by Hugh Copland, Project Manager, Abandoned Mines and Assessment

Mining and the environment are often seen as opposites. But as society has evolved into a more environmentally aware community, so has the mineral industry. The situation in the Yukon is no exception.

Exploration and mining activities in the territory are permitted and monitored by the government. At the exploration stage, activities are governed by the mining land use regulation under the *Quartz Mining Act*. This legislation ensures that environmental disturbances created by mining exploration activities are minimal and any adverse impacts are dealt with.

Increased use of helicopters and other advanced geophysical technologies ensures that mining activities leave a negligible impact. Indeed, significant ore deposits have sometimes been located without anybody ever having set foot on the ground.

Companies that wish to construct a mine go through a rigorous assessment procedure under the *Environmental Assessment Act*, which will be replaced by the *Yukon Environmental and Socio-economic Assessment Act*. First, baseline studies are undertaken to collect information on the natural characteristics of the general area. These include water quality, fisheries, wildlife, vegetation and traditional land uses. Baseline studies are important because they help determine the effects a mine may have on the environment once it is operational.

An environmental review committee, comprised of First Nations and federal and territorial governments, then examines the information. Public meetings are often held in communities closest to the project. The mine will only proceed to the licensing stage after the environmental review committee has reviewed the baseline studies and mine plans, and the government is satisfied that environmental effects will be mitigated.

An important part of the environmental assessment is the abandonment and reclamation plan submitted by the mining company. This plan sets out how the land will be restored after the mine shuts down.

The preferred solution of both mining companies and the public is a "walk away" scenario, where the land is revegetated and no further maintenance is required. In some cases, mining companies, nearby communities, First Nations, and traditional land users may wish to develop reclamation plans that allow for a different use of the land.

For example, the City of Whitehorse has been using abandoned open pits from the old Whitehorse copper mine as landfill sites for a number of years.

Improved wildlife habitats, recreational opportunities or other industrial uses are all feasible post-mining land use options.

Monkshood

Lee Pigage

The fragility of the northern environment makes mining and reclamation an even more challenging aspect of mine planning in the Yukon. Proven southern procedures may not necessarily be a panacea in the north. For example, the heap leach process is common in the southwestern United States and in South America. In the Yukon, the Brewery Creek mine was the northernmost heap leach operation in Canada. Here, extreme winter temperatures necessitated several design changes compared with southern heap leach pads.

The delicate balance between environmental protection and utilization of natural resources is always a challenge, especially for operators in the north who are continuously overcoming difficulties. With innovative thinking, technological advancement and an open dialogue between companies, government and the public, mining can maintain a balance with the environment that benefits all northerners.

ROBERT E. LECKIE AWARD FOR OUTSTANDING RECLAMATION PRACTICES

This award recognizes reclamation and site restoration efforts that go well beyond what is required by law. This may be achieved by companies reclaiming land for which they had no obligation to reclaim; adding features to the land that enhance the area and local community; or returning mined land to a condition that is sound and aesthetically pleasing.

2001 WINNERS

HARDROCK MINING AWARD

NovaGold Resources Inc., Viceroy Resource Corporation and Newmont Exploration of Canada Ltd. shared recognition for their reclamation program on the McQuesten property located on the Elsa airstrip. This property saw cumulative bulldozer trenching between 1962 and 1971, with 6.9 million tonnes of material shipped to the Trail Smelter in 1968. Additional trenching was carried out in 1998. All three companies have supported reclamation work since 2000. This included backfilling approximately 200,000 cubic metres of earth into old trenches, re-contouring land to the original topography and restoring the airstrip. The outstanding reclamation efforts have enhanced both the safety and aesthetic values in the Elsa area.

Aerial view of reclamation at the McQuesten property in the same year that the work was completed.

PLACER MINING AWARD

Doug Busat of T.D. Oilfield Services Ltd. was recognized for his exceptional restorative work since mining began at the mouth of Hunker Creek in 1997. Methodical and progressive reclamation has included placing overburden over old dredge piles and previously mined areas, backfilling old mine cuts and settling ponds with coarse tailings, and topping the area with finer-grained material to encourage natural re-vegetation. The post-mining landscape of wetlands and grasslands are aesthetically pleasing. They provide habitat for waterfowl and wildlife, as well as recreational enjoyment for many tourists and local people travelling the Klondike Placer Loop. The property is an excellent example of responsible and thoughtful placer mining practices.

This landscape, part of the T.D. Oildfield Services Ltd. operation, can be easily viewed from the much travelled Hunker road.

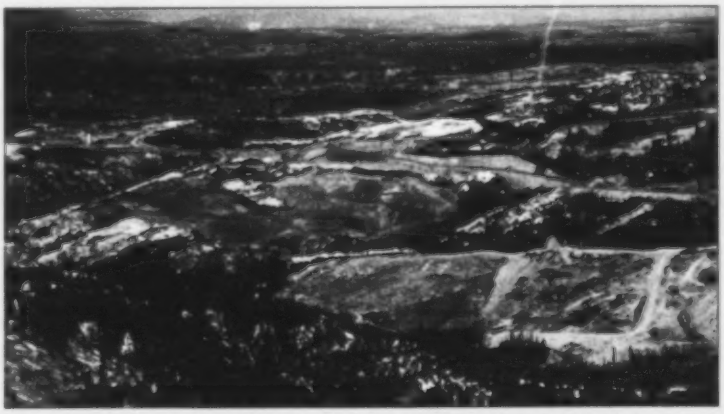
ROBERT E. LECKIE AWARD FOR OUTSTANDING RECLAMATION PRACTICES

This award recognizes reclamation and site restoration efforts that go well beyond what is required by law. This may be achieved by companies reclaiming land for which they had no obligation to reclaim; adding features to the land that enhance the area and local community; or returning mined land to a condition that is sound and aesthetically pleasing.

2002 WINNERS

HARDROCK MINING AWARD

Viceroy Minerals Corporation, Robert E. Leckie award winner in 1999, has once again been recognized for outstanding reclamation practices at the Brewery Creek Mine. All of the reclamation work done at the mine site was of a very high standard and done with pride. Today, the landscape throughout the mined-out area is in stable and aesthetically pleasing form that blends well with the local topography. Growth media has been spread wherever it was available and much of the disturbed areas have been re-seeded. The Brewery Creek Mine provides an excellent example of how modern mining techniques practiced by responsible companies have changed the face of the industry.



Aerial view of reclaimed mine pits at the Brewery Creek mine.

PLACER MINING AWARD

David McBurney has been recognized for his outstanding reclamation practices on the banks of the Indian River. Mr. McBurney has gradually moved his operation upstream along one bank of the river in an organized and systematic fashion. He has reclaimed previous mining disturbances and sacrificed small portions of mineable ground to preserve large trees adjacent to the original riverbank. Progressive reclamation works each year have included backfilling and levelling mining pits, flattening tailings piles, spreading overburden evenly over the whole area, and finally re-contouring and re-vegetating the mined out areas.

David McBurney's restored river bank, with large rock armouring along the bank and overburden spread up to the edge.

ACID ROCK DRAINAGE

Acid rock drainage (ARD) is a natural phenomena which has taken place for millions of years. It occurs when sulphide-bearing rocks are exposed to water and air, producing sulphuric acid.

Where does it occur in the Yukon?

Acid rock drainage develops naturally in the MacMillan Pass, Clear Lake in the Pelly River Basin, and Engineer Creek along the Dempster Highway.

What does it look like?

When ARD is neutralized by natural buffering minerals, the metals precipitate out of the water and form deposits on the stream bottom, or stains on the rocks. Typically these are iron hydroxides, which are bright rusty-red to orange in colour. Copper carbonates have blue, turquoise, or green precipitates.

Names of watercourses on topographic maps may indicate ARD: Ironrust Creek, Red Springs, Red Gulch, and Rusty Creek.

Can mining cause acid rock drainage?

The mining process exposes mine wastes, tailings, or mine workings that sometimes contain sulphides in sufficient quantities to result in acid generation. More surface area is exposed to react with air or water. Some bacteria can increase the rate of acid generation. This process is often referred to as acid mine drainage (AMD).

What problems can acid rock drainage cause?

Acidic water can dissolve metals from the rocks and sediments over which it flows. The main metals of concern in the Yukon are zinc and copper. Some animal species are more tolerant to these metals than others. Animals such as certain insect larvae (mayflies) and salmonoid fishes will be absent from water with elevated levels of metals. Plants can also be stressed from exposure to ARD. This results in stunted, sparse growth, or discoloured leaves.

How can we stop ARD?

If all moisture or oxygen were removed from the sulphide-bearing rock, acid generation would stop. Reducing some bacterial activity would also decrease the rate of acid generation. There are expensive and complex procedures to restrict this contact: permanent flooding of tailings areas and pits; sealing waste rock piles with impermeable covers; and the operation of water treatment plants.

The prevention of ARD at mine sites is more cost effective than the control, collection, and treatment of contaminated water once it arises. The best defense in dealing with AMD is based on prediction and prevention.

Is ARD a problem in the Yukon?

Like other mining regions in Canada, ARD is the most significant issue facing the mining industry in the Yukon. Abandoned mines can continue to generate acid drainage long after operation. Some mining areas in the Yukon have very little or no potential of acid rock drainage, mainly due to the buffering capacity of the host rock. Developing mines are now required to test for the potential of acid generation.

Lee Pigage

Impacts on water and fish habitat quality are part of the environmental studies undertaken.

BIOREMEDIATION: CLEANING UP WITH WETLANDS

Bioremediation is the process of using organisms, including plants and bacteria, to break down and get rid of contaminants. Wetlands act as store houses and purifiers of water, and they provide valuable habitat for waterfowl and other organisms. A natural process cleans up a human-made problem.

What is a wetland?

A wetland occurs at the contact between drier uplands and adjacent water, where the watertable is at or near the surface.

What do wetlands treat?

Wetlands have been used for decades in many parts of the world for the treatment of municipal wastewater (sewage). They significantly reduce sediments, oxygen-demanding substances such as ammonia, and nutrients such as nitrogen and phosphorus. Applications have expanded to include treatment for industrial wastewater.

Can wetlands help treat acid mine drainage?

Yes! Since the 1980s, wetlands have been used in the treatment of acid mine drainage, usually at coal mines. There are a number of examples of natural wetlands used to treat mine waste water in Canada.

- At Silver Queen mine in Smithers, B.C., the wetland receives and treats zinc-contaminated discharges.
- At the Miramar Con Operations, Great Slave Lake, NWT, arsenic, copper and cyanide in the water are reduced as they pass through a series of lakes and muskeg before being discharged into Great Slave Lake.

How do wetlands work?

Soil is one of the most important physical components of a wetland, and it plays a direct role in the removal of metals. Clay is capable of adsorbing metals; organic soils offer little or no potential for the removal of metals. The soils must also support wetland vegetation.

Vegetation plays an indirect role in the removal of metals. Rooted vegetation (i.e. sedges) is used in the Yukon. The roots hold the substrate together, prevent channels from forming, and increase residence time of water in the wetland. The plants also produce detritus which provides habitat and organic matter required by bacteria. As the bacteria decompose the organic matter, anaerobic (without oxygen) conditions allow for some chemical reactions to take place, which increases the alkalinity of the water. The alkalinity neutralizes acid mine drainage, and various metals can precipitate out.

Wetland plant species vary in their ability to accumulate metals. Some may have elevated tissue concentrations while others show little accumulation.

Natural vs constructed wetlands?

Natural wetlands aren't always there when you need them. Sometimes there is a need to design and construct wetlands. This is a lengthy process: one to two years of planning, and a time for the plants to establish in the wetlands before contaminated water is introduced. Wastewater then must be in the wetland system a sufficient time for the biological (microbial), chemical (reduction, oxidation), and physical (sorption) activities to occur.

Will constructed wetlands work in the Yukon's colder climate?

Most of the wetland treatment systems have been designed and used in temperate climatic areas where permafrost, extreme minimum temperatures, and limited plant productivity is not a great concern.

A pilot wetland was constructed in 1995 at the United Keno Hill Mine property to help answer this question. After one season of wetland treatment, initial results showed that the pilot wetland significantly reduced zinc concentrations. Four years later, the wetland was still in existence and supported healthy growth of the transplanted sedges.

BREWERY CREEK: A CASE STUDY

Brewery Creek is different from other traditional hardrock mines in the Yukon because it used the heap leach process to separate the gold from the rock. This allowed for the efficient and economic extraction of gold from deposits with a lower gold content and also cut down significantly on the amount of energy required to extract and transport ore. The mine operated from 1997 to 2001.

At Viceroy Resource Corporation's Brewery Creek mine, the ore was extracted from a series of small to medium-sized open pits instead of one very large excavation. Gold deposits were found in at least eight different zones and several other exploration targets exist for potential additional reserves.

The host rock in which most of the gold was found is called limonitic-altered quartz monzonite. The upper 30 to 40 metres of rock were severely weathered over the last thousands of years. This rock, which crumbles easily, was preserved because the area was not glaciated in the last two million years.

The gold was part of the chemical composition of pyrite (iron-rich) crystals, from which the gold could not be fully recovered. Oxidation (weathering) broke down the pyrite crystals and freed the gold from the original rock. This allowed the gold to be separated by the heap leach process and collected as a separate gold-rich solution.

HOW THE HEAP LEACH PAD WORKED

At Brewery Creek, ore was placed to form a 30-metre high leach pad. A dilute cyanide solution was dripped

Yukon government

Heap leach pad and plant at Brewery Creek mine, 1997. Brewery Creek mine operated from 1997 to 2001.

from perforated plastic pipes about a metre apart onto the ore. The cyanide solution percolated through the rock, dissolved the gold, and carried it down through the heap.

Caustic soda was mixed into the solution to maintain a high pH, which kept the cyanide from evaporating. Lime was also added to the ore when it was placed on the leach pad.

At the bottom of the heap were two composite liners of plastic and compacted silt. This prevented any fluid from escaping. Above the top liner was a series of pipes that collected the solution and, with the help of gravity, transported it to a plant. This was a completely closed system so none of the solution was discharged into the environment. The gold-rich solution from the pad went into the plant where the gold was recovered.

The heap solutions were warmed with exhaust gases captured from a waste oil burner and generator. Heating the solution allowed leaching of ore to continue through winter temperatures as low as -50° Celsius. Ore loading on the heap was restricted to warmer months so that pockets of permanently frozen ore would not form within the heap.

The gold-rich cyanide solution was passed through the adsorption/

Yukon government

Eleanor Van Bibber, first gold pour ceremony, Brewery Creek.

Yukon government

Drip lines were part of the leach pad at the Brewery Creek Mine, 1997.

desorption recovery plant where the gold was extracted with the use of carbon, a by-product of burned coconut shells. Smelting into gold bullion occurred on site. The solution was then reconcentrated with caustic and cyanide, and circulated back to the pad.

Safety measures ensured no leakage

The site originally proposed for the Brewery Creek pad had lots of permafrost. This was a concern. Another site was selected to eliminate the risk of ground instability due to thawing permafrost.

Underneath the pad, two layers of plastic made up of one-millimetre thick, durable, puncture resistant, non-reactive PVC completely isolated the pad from the underlying surface. Beneath each PVC liner was a 30-centimetre layer of compacted silt. Between the liners, in a layer of gravel, was a leak-detection piping system. Solution getting past the first layer would show up in the piping system.

Brewery Creek's double liner system was not common among heap leach pads. Given the extreme conditions of the north, different design criteria had to be followed. A rigorous permitting process resulted in the design specifications for construction of the pad exceeding the industry standard in the south.

Monitoring

On a quarterly basis, ground wells surrounding the lower extent of the leach pad were monitored to detect possible cyanide escaping into the environment. Nearby creeks were sampled on a monthly basis.

The heap leach pad

New sections, or cells, of fresh ore were constantly added to the pad. A treatment facility was built to wash spent ore from the first cells. The water used was treated before discharge. If extreme precipitation caused the amount of solution coming off the pads to become greater than the processing plant could handle, the solution was diverted into one of two ponds. These ponds were also double-lined and equipped with leak detection piping.

An additional overflow pond was designed to handle a complete drain down of the leach pads and the processing plant as well as the run-off from a one-in-100-year snowpack accumulation. Even in that unlikely scenario, everything would remain contained.

Don Murphy

Kokanee zone at the Brewery Creek mine. The weathered rock was mined and processed.

RECLAMATION

At the Brewery Creek mine, the reclamation of waste rock, mined-out pits and used ore was an on-going process. The people involved with reclamation — including the environmental coordinator, the environmental technician and the operations staff — felt fortunate that the ore deposits were mined from a series of relatively small pits instead of one large area. It was easier for reclamation to be on-going, instead of delayed until most or all of the mining was complete.

The sequential mining of a number of ore reserves allowed the backfilling of one pit with the waste rock from the next. Backfilling was the preferred method because it caused less site disturbance and the pit walls ended up re-contoured, which allowed the area to blend into the original landscape.

At Brewery Creek, over 70 per cent of the mine waste rock was disposed of in mine pits. The first pit mined was the Upper Foster's. Because it was smaller than the second reserve, Canadian, a waste rock dump had to be constructed adjacent to the larger pit. Some material from Canadian was also used in the construction of a haul road.

The first step in reclaiming waste rock was to re-contour the slopes with heavy equipment to a stable, gentler slope. Then "growth media," the north's version of topsoil, was spread over the gentler slopes. Seeding, fertilizing, and monitoring of the vegetation growth followed.

Viceroy Resource Corporation

In 1997, Viceroy Resource Corporation was named the environmental leader of the Canadian mining industry by the Social Investment Organization of Canada, a non-profit organization formed in 1989 to promote socially and environmentally responsible investment. The high environmental standards that Viceroy demonstrated in design, startup and operation was also applied to mine decommissioning.

The Canadian waste rock dump was re-contoured, seeded and fertilized in 1997. The environmental staff monitored the area to see what native plants grew. Poplar, wild rose, and lupine commonly colonized disturbed areas. The company also tried to seed native grass species similar to those found locally. It involved school students in a research project to test the successful replanting of local shrub species.

The on-going process of reclamation was a routine part of mining at Brewery Creek. The mine operations group worked the re-contouring in with all their other tasks. Mine planners were thinking ahead to the very end product. It saved time and money and made reclamation and the abandonment plan environmentally and financially sensible.

Vicerory Minerals Corporation was awarded the Robert E. Leckie award for outstanding reclamation practices at Brewery Creek mine in 1999, and again in 2002.

William LeBarge

Waste rock at Brewery Creek was smoothed, re-contoured and seeded. In a few seasons, natural vegetation will colonize the disturbed areas.

CYANIDE

Cyanide is probably the most universally recognized poison, with the possible exception of arsenic. It is produced in nature by a wide range of organisms, bacteria, fungi, and approximately 2,650 plant species.

Some centipedes, millipedes, insects, beetles, moths, and butterflies secrete cyanide to repel predators such as toads and birds.

Some of the common plants that contain cyanide are almonds, kale, lettuce, broccoli, cauliflower, corn, sweet potatoes, and the pits or seeds of cherries, plums, apricots, pears and apples.

Cyanide can also be human-made. It is manufactured from ammonia and natural gas and is also a by-product of the manufacture of acrylic fibres and plastics.

What forms does cyanide take?

Cyanide occurs in many forms. The form most used in mining is sodium cyanide. When it is mixed with water, the pH must be kept above 11 or the poisonous gas, hydrogen cyanide, results.

Strict safety procedures are followed when transporting, storing and handling cyanide products.

How is cyanide used?

Cyanide is a common ingredient in the following products and processes:

- synthetic blue dye (blue jeans),
- fumigant and poison,
- manufacture of nylon, plastic, glass, perfume, soap, fertilizer, paint, animal food and pharmaceuticals,
- surgical dressings,
- anti-cancer preparations,
- drugs to reduce high blood pressure, and
- electroplating (silver and gold plated dinnerware, brass plated bathroom fixtures).

The most familiar use of cyanide is in the mining industry. In Canada, over 90% of the gold mined is extracted using a cyanidation process. Cyanide has been used since 1887 to extract gold, silver, copper, zinc, and molybdenum from ore. It allows for the economical recovery of microscopic metals from low grade ore.

Where has cyanide been used in the Yukon?

Cyanide has been used in mills at the Faro, United Keno Hill, Mount Nansen, Mount Skukum, Ketza River, Venus, Arctic Gold & Silver, and Sa Dena Hes minesites. Cyanide was also used in the heap leaching process at Brewery Creek.

What is done with the waste cyanide and abandoned heap leach pads?

Cyanide can be destroyed, degraded, or detoxified by physical, biological and chemical processes. Some of these processes occur naturally and are called natural degradation.

Prior to the mid-1970s, natural degradation was the only treatment for cyanide in tailings ponds. This method did not work during winter under ice cover, nor did it deal with all forms of cyanide.

Chemical processes are very expensive.

Biological alternatives, using several species of bacteria, are now being studied.

Current research

Good news! A 2000 Yukon MERG (Mining Environment Research Group) study has shown that cyanide-degrading bacteria are naturally abundant in soils at the Brewery Creek Mine site. The bacteria are able to successfully work in our colder climate to bio-degrade cyanide on a processed ore heap. This method is more efficient and economical than conventional chemical processes. More studies were recommended.

We are in daily contact with cyanide through the foods we eat and the products we use. With proper handling, care, and disposal methods, we will not harm ourselves or our environment.

Danièle Héon

Strange things are done in the land of the midnight sun. (Robert Service)

APPENDICES

APPENDIX A. Acts and regulations pertaining to mining in the Yukon

- *Placer Mining Act* allows the staking of placer claims and leases.
- *Quartz Mining Act* allows the staking of mineral claims.
- *Environmental Assessment Act* provides for environmental assessment of proposed projects until the *Yukon Environmental and Socio-economic Assessment Act* is implemented.
- *Yukon Environmental and Socio-economic Assessment Act (YESAA)* will provide a screening and review process for proposed projects. Recommendations will then be made to relevant regulatory agencies.
- *Territorial Lands (Yukon) Act* regulates land use activities. This act does not apply to mineral claims but will apply to the building or maintenance of access roads to mineral properties.
- *Waters Act* regulates water usage and controls the deposition of waste into Yukon waters, bridge and stream crossing. Provisions in water licences often contain requirements related to the land, such as measures to stabilize waste dumps. The Yukon Water Board is responsible for issuing water licences.
- *Fisheries Act* (federal) provides for the protection of fish habitat.
- *Quartz/Placer Mining Land Use Regulations* regulate the disturbances left by exploration programs and placer mining activities. Camp cleanliness and reclamation of trenches or mining cuts, roads and drillpads are mandatory and must comply with the regulations.

Depending on the size and type of the mine planned, the following regulations may apply or the following permits may be needed.

- Activity in areas identified or known to have special wildlife habitat values: permit issued under Section 4 of the *Wildlife Area Regulations* (federal). Environmental assessment is required.
- Activity in a migratory bird sanctuary: permit issued under the *Migratory Bird Sanctuary Regulations* (federal). Environmental assessment is required.
- Building or work such as bridges, dams, boom or causeway in, on, over, through or across any navigable water: the *Navigable Waters Protection Act* (federal) regulates such activities.
- Regulating permits issued for the storage or use of explosives: the *Explosive Act* (federal).
- Approval to use, possess or import prescribed substance devices such as analyzers, chromatographs, calibrators, fixed and portable gauges, industrial radiography, logging, detectors, etc.: radioisotope licence issued under the *Atomic Energy Control Act* and subject to the *Atomic Energy Control Regulations* (federal). Environmental assessment may be required depending on the criteria listed in the *Environmental Assessment Act* or later, in the *Yukon Environmental and Socio-economic Assessment Act (YESAA)*.
- Approval to burn refuse: burning permit issued from April to September under the *Forest Protection Act* (territorial). Environmental impact assessment is required.
- Approval to construct highway access: permit issued under the *Highways Act* (territorial) which includes conditions regarding construction standards and gives permission to carry out construction.
- Oversize trucking (concentrate hauling): *Bulk Haul Regulations* (territorial).
- Archaeological, palaeontological and historic site investigations in the field by an archaeologist: archaeological research permit issued under the *Yukon Archaeological Sites Regulations, Yukon Act* (territorial).
- Fish and wildlife research and surveys: *Fish and Wildlife Research Permit* (territorial).
- Aerial moose or caribou survey: *Sundry Permit under the Wildlife Act* (territorial).
- Permit for fuel storage and handling and registration of stationary fuel tanks greater than 4,000 litres: special waste regulations under the *Environmental Protection Act* (territorial).
- Operation of a diesel engine underground: permit issued under the *Blasting Regulations* (territorial).
- Installation of plumbing in the camp: plumbing permit under the *Canadian Building Code, Building Standard Act and Regulations* (federal).
- Building permit for areas not included in municipal bylaws: building permits must meet criteria under the *National Building Code of Canada, Building Standard Act and Regulations* (federal).
- Electrical approval: electrical permit must meet *Canadian Electrical Code, Electrical Protections Act and Regulations* (federal).
- Mixing and dilution, generation, handling, release or disposal of large quantities of special wastes: special waste permit issued under the *Environment Act* (territorial).

APPENDIX B. Glossary

accrete: The process of colliding tectonic plates.

acid mine drainage (AMD): Essentially the same as acid rock drainage, although a greater surface area of sulphide rock is exposed to oxygen and water through mining activities.

acid rock drainage (ARD): Natural or human related process that results in chemical changes or oxidation of rock. Water with a lower pH draining over sulphide rock will dissolve metals in the rock. The three necessary components of acid rock drainage are oxygen, water and sulphide bearing ore.

adit: An opening driven horizontally into the side of a mountain to provide access to a mineral deposit.

alloy: A compound of two or more metals.

assay: To confirm the percentage of a metal in a sample. This is expressed as grams/tonne, ounces/ton, ppm (parts per million) or ppb (parts per billion). If the percentage of metal in a sample is very high, it may be expressed as a per cent (%).

benthic invertebrates: Invertebrates (organisms without a backbone) that live in the substrate of a watercourse.

bioremediation: The process of using organisms, including plants and bacteria, to break down and get rid of contaminants.

breccia: A type of rock in which angular fragments are imbedded in fine grain sediments.

carat: A unit of weight of gemstones. One carat is 200 milligrams. A carat can be compared in size to the eraser at the end of a pencil.

claim: Land held by a prospector or mining company. In Canada, a claim is typically 16 hectares (40 acres).

commodity: Usually refers to a raw material or primary product, such as copper, gold, coffee, sugar and cotton, that is traded on the free market.

concentrate: A fine, powdery product of the milling process containing a high percentage of valuable metal.

craton: Very old, underlying, stable rock of the Canadian Shield.

exploration: The finding of new ore or mineral deposits. There are two types of exploration. Surface exploration does not alter the landscape. Underground exploration removes rock and can disturb the landscape.

gross domestic product (GDP): The value of all goods and services produced in the economy during a given time period.

hardrock mining: A process that requires crushing and processing of rock to separate valuable minerals from the rock.

heap leach: A method of separating valuable metals (usually gold) from an ore heap on a pad. A diluted sodium cyanide solution is percolated through the ore and the metal rich solution is collected at the bottom of the pad.

high grade: An ore deposit near the surface with a high content of valuable metals.

lava: Molten rock extruded upon the earth's surface.

low grade: A less concentrated or more dispersed ore deposit that is expensive to extract.

metal: A compound or element with definite physical properties and chemical composition. Gold, silver, copper, lead and zinc are examples of metals.

mill: A processing plant in which minerals are recovered from the ore.

mineral: A naturally occurring compound or element with definite physical properties and chemical composition and, if formed under favourable conditions, a definite crystal form. Minerals can contain important metals that are mined as resources.

mitigation: An attempt to reduce damages to the environment.

ore, ore body, ore deposit: A mixture of economically valuable metals and worthless minerals from which at least one metal can be extracted at a profit.

placer mining: The process of using water and gravity to separate heavier metals such as nuggets or flakes of gold from the surface.

pluton: Rock of igneous origin that was implaced at some depth in the earth's crust. It may be exposed at the surface by erosion.

rock: Aggregates of two or more minerals.

sluice: The process of allowing gold to settle out while washing away gravel, sand and clay with water.

smelt: The use of heat and energy to extract the metals from the minerals.

reclamation: The restoration of a site after mining or exploration is completed.

refining: The final preparation of metals before manufacture.

stakeholder: An invested interest in a mine property.

sulphide: Minerals that combine with sulphur (S), for example, galena (PbS) and pyrite (FeS).

tailings: The material rejected after the valuable minerals have been extracted from the ore. The tailings are the fine particles collected in the tailings ponds.

terrane: Any rock formation or series of formations bounded by faults and distinct from surrounding rocks.

waste rock: Rock with a low content of valuable minerals. It is usually heaped in piles.

APPENDIX C. Mineral Resources

The Oil and Gas and Mineral Resources Division of the Department of Energy, Mines and Resources is responsible for the development and management of Yukon minerals. Two branches administer the mineral resources programs.

The responsibilities and services of the **Minerals Management Branch** include:

- issuing and maintaining mineral titles;
- reviewing work filed for assessment credit;
- selling claim maps and providing information on land status;
- developing and implementing regulations governing mining and exploration activities; and
- screening and approving proposed developments.

The responsibilities and services of the **Minerals Development Branch** include:

- carrying out the basic functions of a geological survey;
- administering the Yukon Mining Incentives Program;
- providing information on the Yukon Mineral Exploration Tax Credit and the Mining Environment Research Group; and
- disseminating information on the Yukon's exploration and mining industry, through initiatives such as the Yukon Regional Mineral Development Program.

Mining inspections are carried out under Client Services and Inspection Branch.

For more information,
e-mail: mining@gov.yk.ca

INCENTIVES

The Yukon offers one of the best incentive programs in Canada.

Yukon Mineral Exploration Tax Credit

The Yukon Mineral Exploration Tax Credit is a refundable corporate and personal income tax credit of 25% of eligible mineral exploration expenditures incurred by eligible individuals and corporations conducting off-minesite exploration in the Yukon between April 1, 2001 and March 31, 2004.

Information is available from:
Department of Finance
phone (867) 667-3074 or
toll free in the Yukon
1-800-661-0408, ext.3074
e-mail: ymetc@gov.yk.ca
www.emr.gov.yk.ca/Mining/TaxationAndRoyalties/MineralExplorationTaxCredit.htm

Yukon Mining Incentives Program

This program is designed to promote and enhance mineral prospecting, exploration and development activities in the Yukon, providing a portion of the risk capital required to locate and explore mineral deposits. Technical assistance is offered to the industry, upon request, by the Yukon Geological Survey staff.

phone (867) 667-5996 or
toll free in the Yukon
1-800-661-0408, ext. 5996
2099 Second Avenue, Whitehorse
e-mail: ymip@gov.yk.ca
www.emr.gov.yk.ca/Mining/YMIP

Assay Coupon Program

The Assay Coupon Program promotes and supports grassroots mineral prospecting and exploration activities in the territory. Prospectors can receive coupons towards the cost of an assay or analysis. The Assay Coupon Program complements the government's Yukon Mining Incentive Program (YMIP) by supporting prospectors who do not apply or qualify for YMIP. It also provides assistance to YMIP applicants who do additional exploration outside of their approved programs.

To obtain coupons:
phone (867) 667-5996 or
toll free in the Yukon
1-800-661-0408, ext. 5996
2099 Second Avenue, Whitehorse
e-mail: ymip@gov.yk.ca
www.emr.gov.yk.ca/Mining/Assay/
or contact your district Mining Recorder office

Mining Environment Research Group
MERG is a cooperative working group made up of government agencies, mining companies, Yukon First Nations and non-government organizations for the promotion of research into mining and environmental issues in the Yukon. MERG accepts applications each spring. Reports are available for viewing at www.emr.gov.yk.ca/Mining/MERG and in all Yukon libraries. They are also available for purchase at the Map Publications desk 102-300 Main Street, Whitehorse.

For more information:
phone (867) 456-3808 or
toll free in the Yukon
1-800-661-0408, ext. 3808
e-mail: merg@gov.yk.ca

Robert E. Leckie Award
The Robert E. Leckie Award for Outstanding Mining Reclamation Practices recognizes reclamation and restoration efforts that go well beyond what is required by law, either by reclaiming land for which the operator has no obligation to reclaim, adding features to the land that enhance the area and local community, or returning mined land to a condition that is not only sound but aesthetically pleasing.

For more information:
e-mail: mining@gov.yk.ca
www.emr.gov.yk.ca/Mining/IncentivePrograms/Leckie/

REFERENCES

Energy, Mines and Resources

Yukon Mineral Exploration Tax Credit Bulletin.

Yukon Annual Statistical Review.

Yukon Exploration and Geology, Yukon Geological Survey, January, 2003

Yukon Mineral Property Update, January, 2003.

Yukon Mineral Deposits, January, 2003.

Yukon Short-term Economic Outlook 2003.

Yukon Diamond Rumour Map and Notes, 2002.

Devolution Fact Sheet: Mineral Resources

To order:
Energy, Mines and Resources
Suite 400-211 Main Street
Box 2703
Whitehorse, Yukon Y1A 2C6
phone (867) 667-5200 or
toll free in the Yukon
1-800-661-0408
fax (867) 667-5150

Yukon Geological Survey
Publications include federal and territorial reports and maps on the regional bedrock mapping, mineral deposits, placer deposits, mineral assessment, gemstone exploration, geochemical, geophysical and environmental studies.

To order:
Geoscience Information and Sales
phone (867) 667-5200
fax (867) 667-5150
e-mail: geosales@gov.yk.ca

Yukon Mining Recorder
Mining Recorders' offices are located in Whitehorse, Dawson City, Mayo and Watson Lake. The four district offices provide staking guidelines, information sheets, and assistance and information on ground open for staking.

Information is available at www.yukonminingrecorder.ca, or
Whitehorse Mining Recorder
300 Main Street, Suite 102
Box 2703
Whitehorse, Yukon Y1A 2C6
phone (867) 667-3190 or
toll free in the Yukon
1-800-661-0408
fax (867) 667-5150
e-mail: whitehorsemining@gov.yk.ca

WEB SITES

Energy, Mines and Resources
www.emr.gov.yk.ca
or
yukonmining.com

Yukon Geological Survey
www.geology.gov.yk.ca

Mining Recorder
www.yukonminingrecorder.ca

Geomatics Yukon
www.geomaticsyukon.ca

APPENDIX D. Contacts

The area code for the Yukon is 867.

DEPARTMENT OF ENERGY, MINES AND RESOURCES
MINERALS RESOURCES DIVISION

400-211 Main Street, Box 2703
Fourth Floor, Shopper's Plaza
Whitehorse, Yukon Y1A 2C6
Phone 456-3830
1-800-661-0408, ext. 3830

Minerals Management Branch

Fax 456-3899

Director
Phone 667-3126

Mining Land Use Officer
Phone 456-3961

Manager, Mining Lands
Phone 456-3822

Dawson Mining Recorder

1242 Front Street, Box 249
Dawson City, Yukon Y0B 1G0
Phone 993-5343
Fax 993-6747

Mayo Mining Recorder

6th Avenue and Centre Street
Box 96
Mayo, Yukon Y0B 1M0
Phone 996-2256
Fax 996-2217

Watson Lake Mining Recorder

Box 269
Watson Lake, Yukon Y0A 1C0
Phone 536-7366
Fax 536-7842

Whitehorse Mining Recorder

102-300 Main Street, Box 2703
Whitehorse, Yukon Y1A 2C6
Phone 456-3823
Fax 667-5150

Geoline Publication Sales
Phone 667-5200

Mineral Development Branch

400-211 Main Street, Box 2703
Fourth Floor, Shopper's Plaza
Whitehorse, Yukon Y1A 2C6
Phone 667-8256
Fax 667-8601

Director, Mineral Planning and Development
Phone 667-3422

Yukon Geological Survey

2099 Second Avenue, Box 2703
Whitehorse, Yukon Y1A 2C6
Phone 667-5809
Fax 393-6232

Manager
Phone 667-5384

Chief Scientist
Phone 667-3200

OTHER USEFUL CONTACTS

Topographical map sales
Mac's Fireweed Books
Phone 668-6104
Toll-free 1-800-661-0508

Yukon Prospectors Association
Phone 668-7985
ypa@northland.com

Klondike Placer Miners' Association
Phone 667-2267
Fax 668-7127
www.kpma.ca

Yukon Chamber of Mines
Phone 667-2090
Fax 668-7127
ycmines@yukon.net
www.yukon.net/ycmines

National Air Photo Library
615 Booth Street
Ottawa, Ontario K1A 0E9
Phone 1-800-230-6275
napl@NRCan.bc.ca

Yukon
Energy, Mines and Resources

YUKON
GEOLOGICAL SURVEY